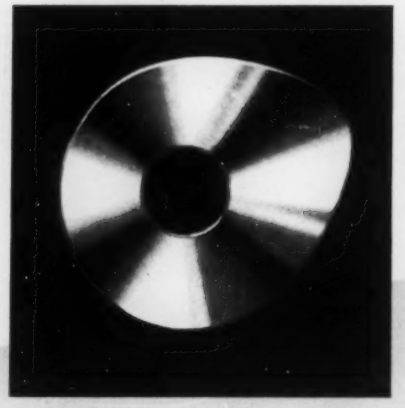
MARCH 7, 1957
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION

$$M\frac{d^2x}{dt^2} + (b+c)\frac{dx}{dt} + Kx = b\frac{dx_f}{dt} + Kx_f$$



Designing with Electronic Computers

Contents, Page 3

FARNSWORTH

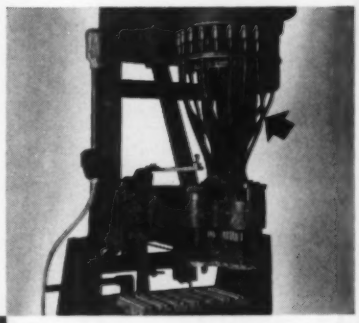
S.S.White

Flexible Shafts Step Up Design Efficiency

The manufacturer of this multiple spindle drill press finds that S.S. WHITE FLEXIBLE SHAFTS allow a wide range of positions for different drilling jobs.

This is only one example of the versatility . . . efficiency . . . and freedom S.S. WHITE FLEXIBLE SHAFTS are bringing to hundreds of industrial designs. The restrictions imposed by rigid shafting are eliminated. With flexible shafts you position power sources . . . driven members . . . controlled parts to better advantage. By simplifying methods of connection and adapting, costs can be reduced. Assembly is cheaper . . . alignment problems are eliminated . . . and product efficiency is often greatly improved!

Consider your own product. Chances are, S.S. WHITE FLEXIBLE SHAFTS are the simple, economical answer to your power drive and control problems. S.S. WHITE FLEXIBLE SHAFTS are noted for quality, performance and dependability. For more information and expert assistance in selecting and applying an S.S. WHITE flexible shaft to your product, just write to



S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

USEFUL DATA on how to select and apply flexible shafts! Write for Bulletin 5601.

S. S. White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N.Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

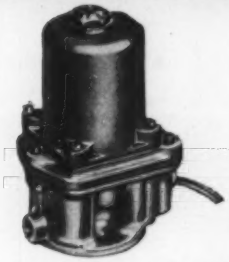
Circle 401 on page 19

NEW **Ross** — **Starline**

air control valve series

NEW **long life**

WHITE STAR
SPOOL SOLENOID



GOLD STAR
OIL-IMMERSED SOLENOID

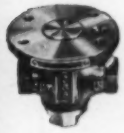
BLUE STAR MV

BLUE STAR TD

BLUE STAR WV

NEW **match any head to any valve body!**

STRAIGHTWAY NORMALLY OPEN

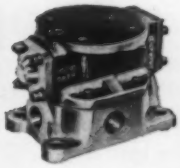


STRAIGHTWAY NORMALLY CLOSED

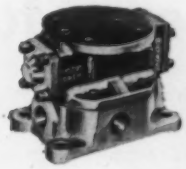
3 WAY NORMALLY OPEN

3 WAY NORMALLY CLOSED

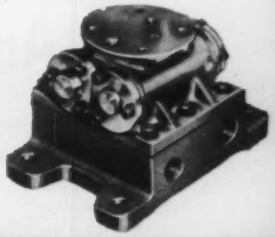
3 WAY NORMALLY OPEN



3 WAY NORMALLY CLOSED



4 WAY



Tests indicate a trouble-free life of over 25 million cycles for valves with the spool solenoid pilot section, and *more than 40 million for all other Starline* valves shown.

Heads and bodies are completely and instantly interchangeable. Sizes from ¼" to 1¼". Even *more* Starline models coming later. Write for Starline data file.

A Galaxy of New Air-Control Stars Are Coming Your Way From

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICHIGAN

Circle 404 on page 19

GOODYEAR INDUSTRIAL PRODUCTS
G.T.M.-Specified
Molded Flange-Wrap Golf Grip
A
Hard, tough cap molded to size
B
Built-in, two-way taper assures perfect taper of grip on club without listing
C
Suede-finished, sun- and sweat-resistant rubber permits firm, comfortable grip

Answer to a gripping problem!

YOU'RE a man with an idea.

You want to market a new kind of golf grip. It will be a strip of rubber that simply wraps on the bare club shaft—no adhesive or listing needed. And, because the rubber will be under tension, it will secure the grip, absorb shock, add distance to drives.

You know what you want, but not how to get it. You try several specialty rubber molders, with little success. Finally, because of his wide experience in successfully solving many specific problems with molded rubber, you turn to the G.T.M.—Goodyear Technical Man—for help.

He works closely with you, suggests improvements in designs, develops a special compound with a suede finish. Result: Now, the grip does everything you hoped it would and more—actually improves with age. Your idea is a fact!

Another fact: The G.T.M. can be of material help on any molded rubber problem, whether it involves engine mounts, shock absorbers, seals, diaphragms or a host of other industrial items. Contact him, today, by writing Goodyear, Industrial Products Division, St. Marys, Ohio, or Akron 16, Ohio.

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MOLDED GOODS by

GOODYEAR

THE GREATEST NAME IN RUBBER

Circle 405 on page 19

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

March 7, 1957
Volume 29—No. 5

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Subscriptions in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio.

Accepted as Controlled Circulation publication at Cleveland, Ohio.

When requesting changes of address, etc., please allow four to six weeks for processing.

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SUBMINIATURE GLENNITE
ACCELEROMETERS

Typical specifications:

- Acceleration Range: .1 to 1200 g's (certain types)
- Sensitivity: 5 mv/g (with cable)
- Resonant Frequency: 10 kc
- Useful Frequency Range: 3 to 3,500 cps
- Temperature Stability: less than 10% sensitivity variation from −40° c to +90° c
- Linearity: ±10% over specified range
- Maximum Sensitivity Direction: axial
- Weight: as little as 3 grams

THE DESIGN ENGINEER'S CHOICE . . .

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Illustrated above is a typical measurement systems application; it consists of a GLENNITE A-320 Accelerometer with matching F-410M Airborne Amplifier and F-11 Filter . . . all connected with GLENNITE Low-Noise Cables and Subminiature Connectors.

Particularly valuable for ground take-off measurements in experimental missile work, this system may also be used for accurate studies of structural member vibration, high acoustic energy vibrations and acceleration measurements of electronic equipment. The output of ±1.5 or ±2.5 volts from the F-11 Filter is sufficient to drive a variety of readout devices.

As an aid to better designing, we have prepared further technical information about many GLENNITE environmental test instruments and associated systems. It is given in Catalog #157; send for your copy.

. . . FROM RAW MATERIALS TO COMPLETE SYSTEMS

Gulton Industries, Inc.

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CONTI

Circle 406 on page 19

Engineering News Roundup

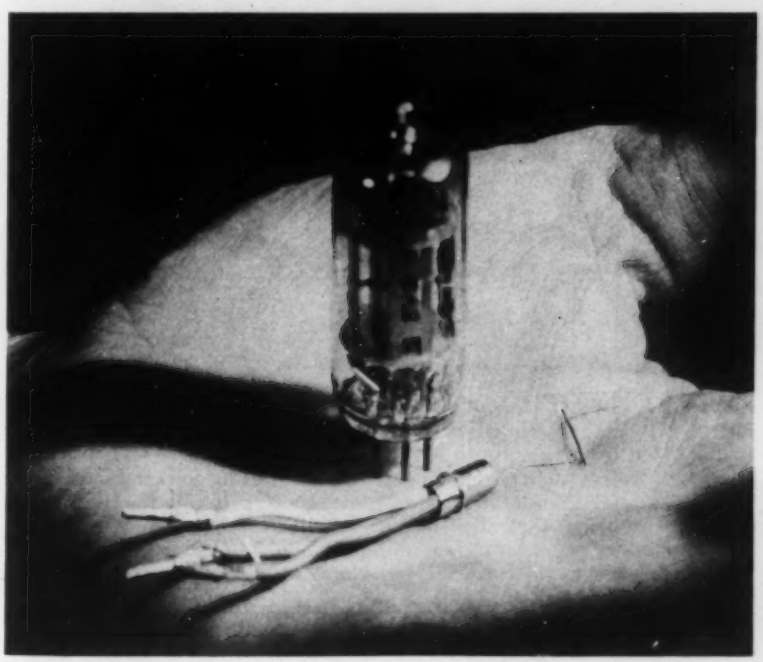
Ultrasmall Electronic Device Can Replace Transistors

Requires Temperatures Near Absolute Zero

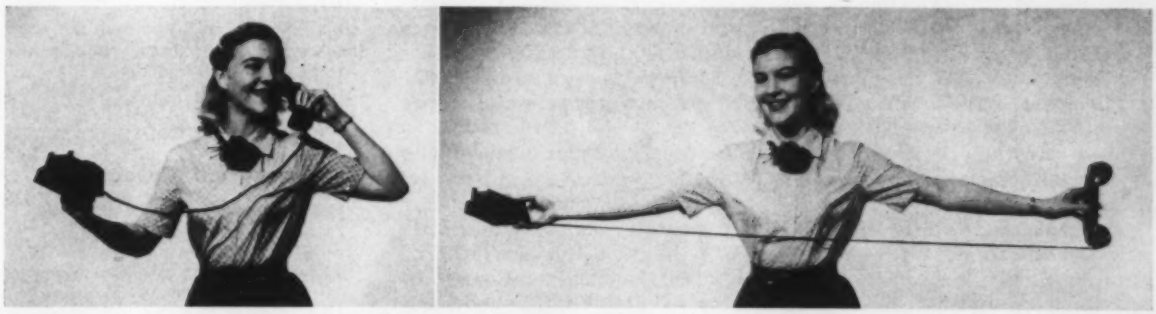
CAMBRIDGE, MASS.—Substantial size reduction of digital computers is in prospect with the recent announcement of a new electronic device, called a cryotron, so small that 100 will fit into a thimble. When cooled below −420 F, the cryotron does the work of vacuum tubes and transistors.

The cryotron was developed at Massachusetts Institute of Technology by Dudley A. Buck. It is the first practical use of superconductivity — the ability of some metals to conduct current, with no resistance, at extremely low temperatures. In the first application of cryotrons, 215,000 will be used in a data-processing machine under construction by Arthur D. Little, Inc.

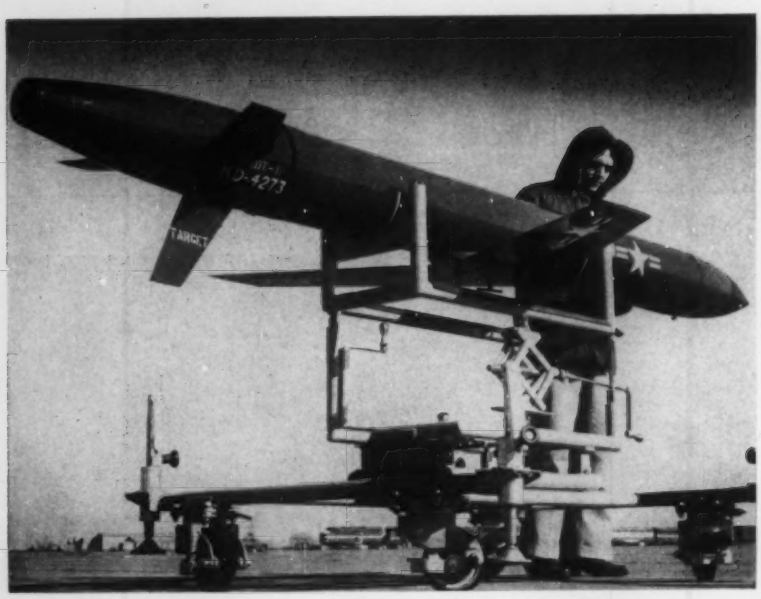
In simplest form, the cryotron is a coil of fine wire wound around a core of straight wire. Below −420 F, the straight wire conducts current with no resistance. Current in the control winding, however, produces a magnetic field which destroys superconductivity in the straight wire, causing its resistance to return. Thus, current in the control winding cuts off current in the straight wire. Families of these single switches com-



Smallest of these electronic components is a cryotron—a coil of fine wire wrapped around a straight piece. Below the vaporization temperature of helium, it operates like a vacuum tube or transistor. It suggests much smaller digital computers even though refrigeration equipment must be used.



NO COILS OR KINKS occur in this new electric cord which can be drawn to three times its relaxed length. The new product has been developed by Mutual Electronic Industries Corp. and is called Elasticable. It has a rubber core around which a conductor such as copper wire is wound or braided. Outside coating is glass fiber, rayon, silicone rubber or nylon. Varied colors and sizes are available. About 6 in. is enough for a telephone.



PRACTICE ENEMY, this new drone missile target is designed for launching from carrier based aircraft. Its vertical stabilizer is on the underside to enable launching from planes. The missile is designated XKDT-1. Its length is 12 ft, wingspread 58.8 in., and body diameter 10 in. Rocket-powered, the XKDT-1 attains a speed of Mach 0.95 at 50,000 ft. It will appear on radar as a full-size plane. Evaluation quantities built by Temco Aircraft Corp. are currently under test at the Naval Air Missile Test Center, Point Mugu, Calif. Low cost makes XKDT-1 suitable as an expendable target.

prise the kind of switching circuits needed for many computers.

Cryotrons are held below −420 F by liquefied helium which boils at 4.2 F above absolute zero. One part of any cryotron computer will be a special refrigerator, known as a cryostat, to liquefy helium and generate the low operating temperature.

The small size of a cryotron is only one of its advantages. A more important characteristic is basic simplicity. Cryotrons can be made by automatic machines at great speed. They can also be made and pre-assembled in long chains. Another cryotron advantage is its low electric power consumption.

A disadvantage of the cryotron at present is its slow speed. Today cryotrons use wires of tantalum and niobium. Both these metals are stronger than copper and become superconductive at liquid helium temperatures. New metals and alloys may enable faster operation.

New Synthetic, Diamond-Hard, May Cut, Polish Metals Faster

Borazon Takes Heat That Burns Natural Gem

NEW YORK, N. Y.—Hardness equal to that of natural diamond is the outstanding property of a new material recently announced by the General Electric Research Laboratory. Called borazon, the new material is boron nitride formed with cubic crystal structure by means of "superpressures" above 1,000,000 psi and temperatures above 3000 F.

Borazon scratches diamond with ease and remains hard at temperatures where diamond is consumed. The scratch tests and other methods prove that the new material is in the same general range of hardness as diamond and thus many times harder than the next-ranking materials in the hardness scale. In actual lapping tests, borazon powder has polished away

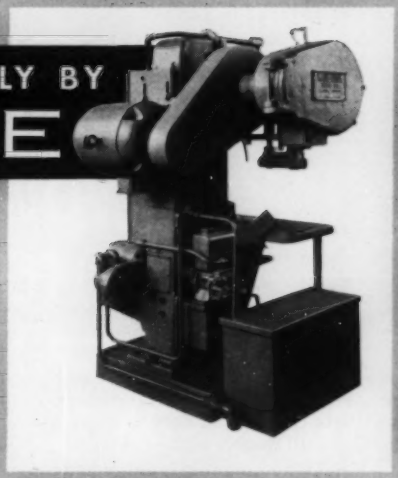
LARGEST ELECTRON TUBE, 10 ft 5 in. long, is capable of generating 100,000 w of average radio frequency power and more than 1 million w at peak pulse power. The super-power klystron, designated X626, was developed by Eitel-McCullough, Inc. and will be used in radar and linear accelerator equipment.

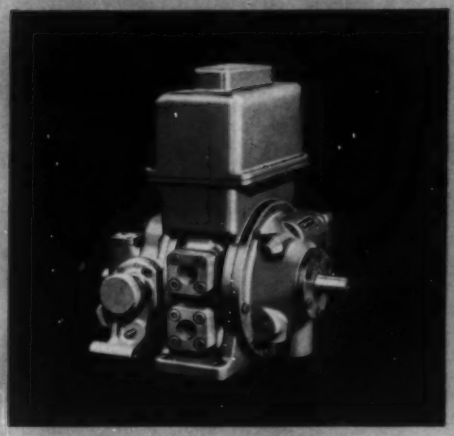
Front Cover

Used in design, computers can be handy gadgets to transform an equation into the data necessary for an actual part. Using this theme, artist George Farnsworth has symbolized the "design" of a cam with a computer. Featured article is "High-Speed Electronic Computers" by L. Sigfred Linderoth Jr. on Page 72.

OILGEAR "JK" FEED PUMPS

USED EXTENSIVELY BY MOLINE



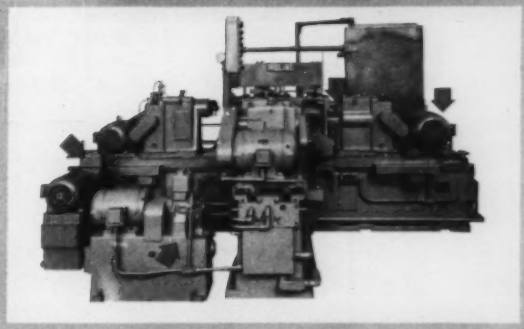


Above, Moline Drilling Machine employing "JK" Feed Pump.

The Moline Tool Company, long established and respected in industry, has used Oilgear Fluid Power Feeds since 1925. Of Oilgear "JK" Fluid Power Feed Pumps used in its machines, Moline says these pumps *combine* the advantages found only in part in various mechanical feeds. Also, the "JK" Feed Pump provides infinitely, steplessly variable speeds; you can easily find the speed best suited to the work or condition of tools. Traverse speed can be as much as 265 times the feed rate. Coarse and fine feed rates are variable over a 20 : 1 range. Cycle time is cut drastically, production increased, costs reduced. Feed rates are maintained accurately despite varying work pressures by a built-in automatic pressure compensator.

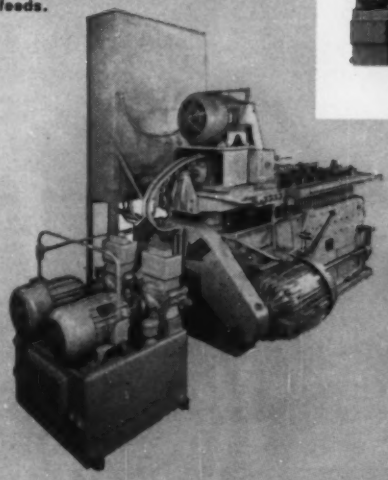
"JK" Feed Pumps are simple, compact, electro-hydraulically controlled units, easily installed nearby or remotely. Systems need only a pump with reservoir, a double-acting cylinder, standard control and two easily connected pipes. Eliminating expensive engineering, these units can simplify design, reduce manufacturing cost, improve performance and increase saleability of machines. Manual, semi-automatic or full automatic operation. Available now in 4 sizes. Write for free literature.

THE OILGEAR COMPANY
1568 West Pierce Street
Milwaukee 4, Wis.

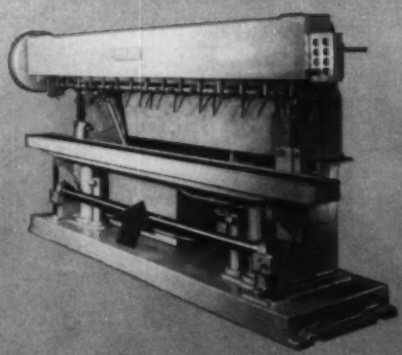


Moline 4-way horizontal boring machine uses 4 Oilgear "JK" Feed Pumps.

Below, Moline special 58-spindle back-spotfacing machine using 2 "JK" units for vertical and horizontal feeds.



Below, Moline ten-foot, straight-line drilling machine using "JK" Feed Pump.



"JK" PUMPS EASILY APPLICABLE TO YOUR MACHINES FOR BETTER PERFORMANCE

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OILGEAR
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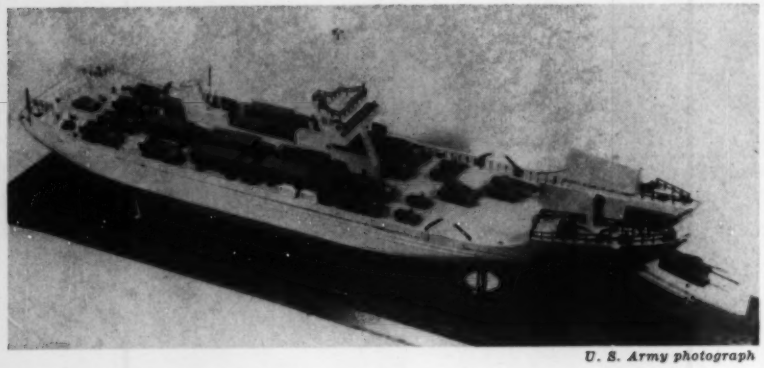
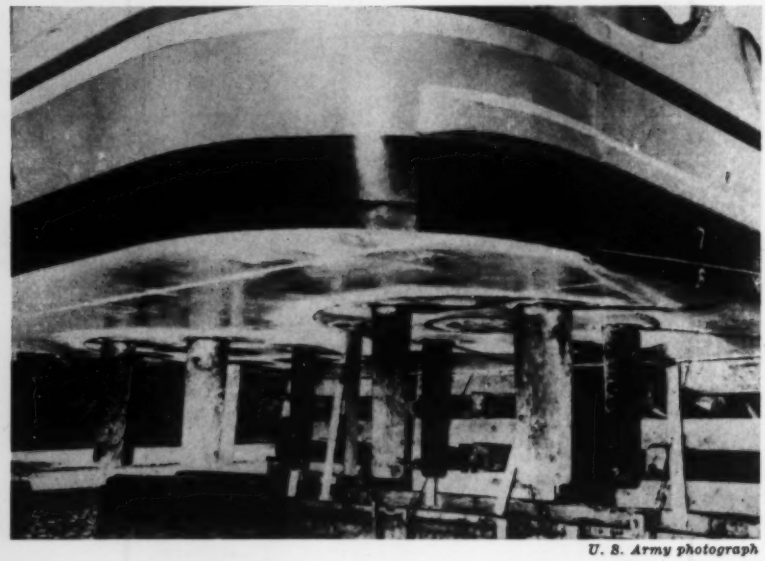
PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



U. S. Army photograph

SELF-RETRACTING BEACH LIGHTER, under construction for the Army, is expected to speed up landing operations. Designated BDL-1X, the ship will carry 600 tons of vehicles or 1000 tons of bulk cargo from ship to shore, between ships, and across oceans. Length of the BDL-1X will be 338 ft; beam 65 ft. Speed with full load will be 12 knots and cruising range, light loaded, 4800 miles. Each of the ship's two 1200-hp diesel engines will drive a six-bladed vertical-axis propeller, below, used for both steering and propulsion. The propellers will provide unusual maneuverability and enable the ship to withdraw itself from a beach. A hydraulic ram at the bow will help.



U. S. Army photograph

the surface of a large diamond at the same rate as diamond powder.

In another important characteristic, borazon appears to be superior to nature's hardest substance. Diamond, which is basically carbon, burns in air at about 1600 F. Borazon can withstand temperatures of more than 3500 F.

GE expects that borazon's resistance to oxidation will make possible superior methods of mounting stones in industrial tools and also may allow bits and wheels to be operated at higher speeds, thereby performing cutting and polishing jobs more quickly and efficiently.

The first borazon publicly exhibited consists of tiny crystals no larger than grains of sand. The color of borazon is generally black, brown or dark red, although milky white, gray and yellow crystals have been made.

X-ray diffraction tests of borazon reveal that alternate atoms of boron and nitrogen are packed together almost as closely as the carbon atoms in diamond. The

Topics

His and Hers television sets, designed for those fabulous folks who "have everything," are being considered for production by Motorola. The feminine version of the experimental 14-in. portable sets has a pink leather covering and rhinestone-studded controls and carrying handle. "His" set is covered in black and white pony skin, and the carrying handle is hand-engraved in the manner of a fine pistol or shotgun.

• • •

Endurance and altitude records were set recently by a jet drone target missile which reached 53,000 ft and remained in the air on remote control for 104½ minutes. Flight of the Ryan XQ-2B Firebee, controlled by a new autopilot, included a 7½-minute glide under remote control after fuel was expended and prior to release of the parachute which is provided for recovery of the missile.

• • •

Installation of a gas turbine engine has been made in a new tilt-cab Ford truck. The experimental model is undergoing developmental tests aimed at improvements such as increased fuel economy.

• • •

Engineer's vocabulary is sought by a business college, to be used in a training program for engineering secretaries. Terminology and technical information in the form of carbon copies of dictation, instruction booklets, employee manuals, dictionaries or lists of specific terminologies, technical specifications, research reports and industrial books are being solicited by the dean for use in dictation and transcription training. Correspondence may be sent to Dean Phyllis E. Davis, Business Training College, Wood St. and the Boulevard of the Allies, Pittsburgh 22, Pa.

• • •

Automobile air conditioning grows increasingly popular, according to a report from Dodge. Orders for 1957 cars with Dodge's new, compact combination heater and air conditioner exceed 90 per cent of the total number of air-conditioned Dodges sold during the 1956 model year.

Circle 407 on page 19→

BOUND BROOK KNOW-HOW, PLUS ROTO-LOK QUALITY *BLASTS* DESIGN, COST *BUG-A-BOO*

PROBLEM: Certified Gas Equipment Corp., manufacturers of Roto-Lok valves, needed a simple, trouble-free gas valve rotor with consistent dimensional stability that could be produced economically.

SOLUTION: Bound Brook engineers, working with Roto-Lok, successfully made the part from their versatile **POWDIRON** material. **POWDIRON** is easily molded to the irregular rotor shape and costs much less than machine-made rotors.

RESULT: Bound Brook powder metallurgy experience helped Roto-Lok secure a "must" part quickly at low cost. How about you?

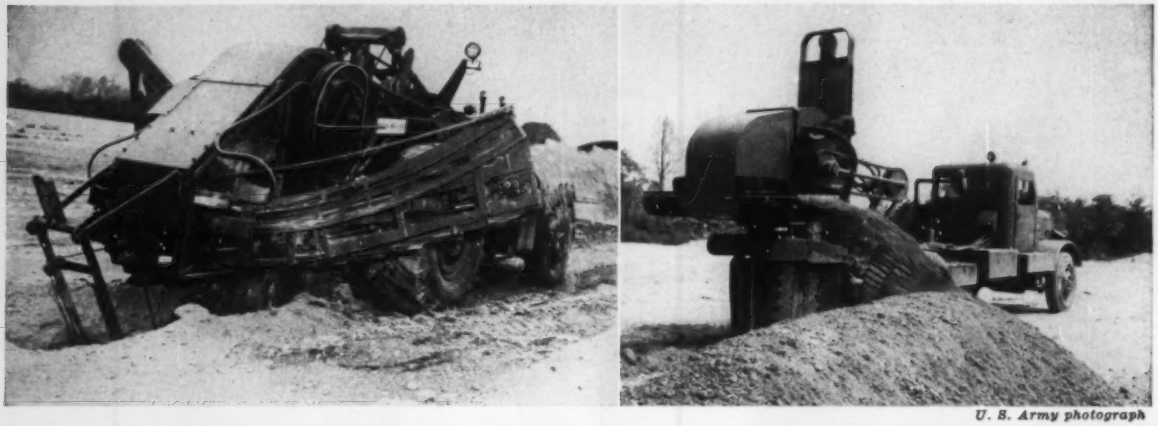
BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

ESTABLISHED 1883



U. S. Army photograph

TRENCHES, IN A HURRY, are dug by these mobile ditching machines currently under test at the Corps of Engineers' Research and Development Laboratory. Equipment manufactured by Barber-Green Co., left, and Owen-Pewthers Co., right, may be useful in providing protection for soldiers and civilians against flash burns, fragmentary bombs and radioactive blast. Both machines are rubber-tired for rapid movement on highways; have multiple buckets with interchangeable insert-type teeth; dig to depth of 6 ft and make a foxhole in 30 seconds. Barber-Greene model digs 28 ft of trench per minute. Owens-Pewthers unit digs 24 ft per minute.

density is also about the same (specific gravity: 3.45 for borazon, 3.50 to 3.56 for diamond).

Borazon is not being announced as a new product, according to Dr. C. G. Suits, GE vice president and director of research. "It is a major scientific achievement—the creation of a new material never observed in nature, with properties equalling or surpassing those of a material long thought to be the 'ultimate'."

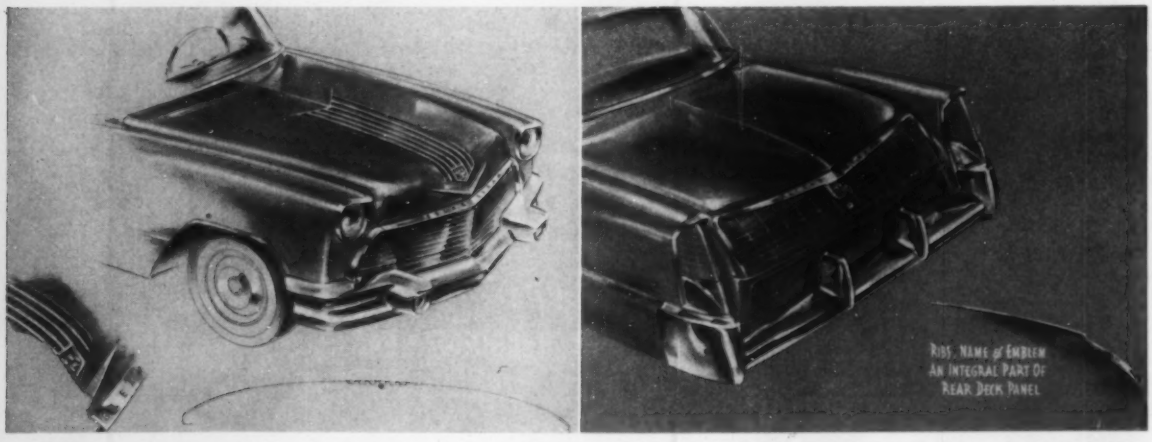
Plans Under Way for Fourth Mechanisms Conference

CLEVELAND, O.—Well advanced in the planning stage is a Fourth Conference on Mechanisms to be sponsored by the School of Mechanical Engineering of Purdue University and MACHINE DESIGN.

Dates of the Fourth Conference on Mechanisms are Thursday and Friday, May 16 and 17.

Success with the first three conferences in 1953, 1954 and 1956 has guided planners of the fourth in arranging for papers of direct concern to design engineers.

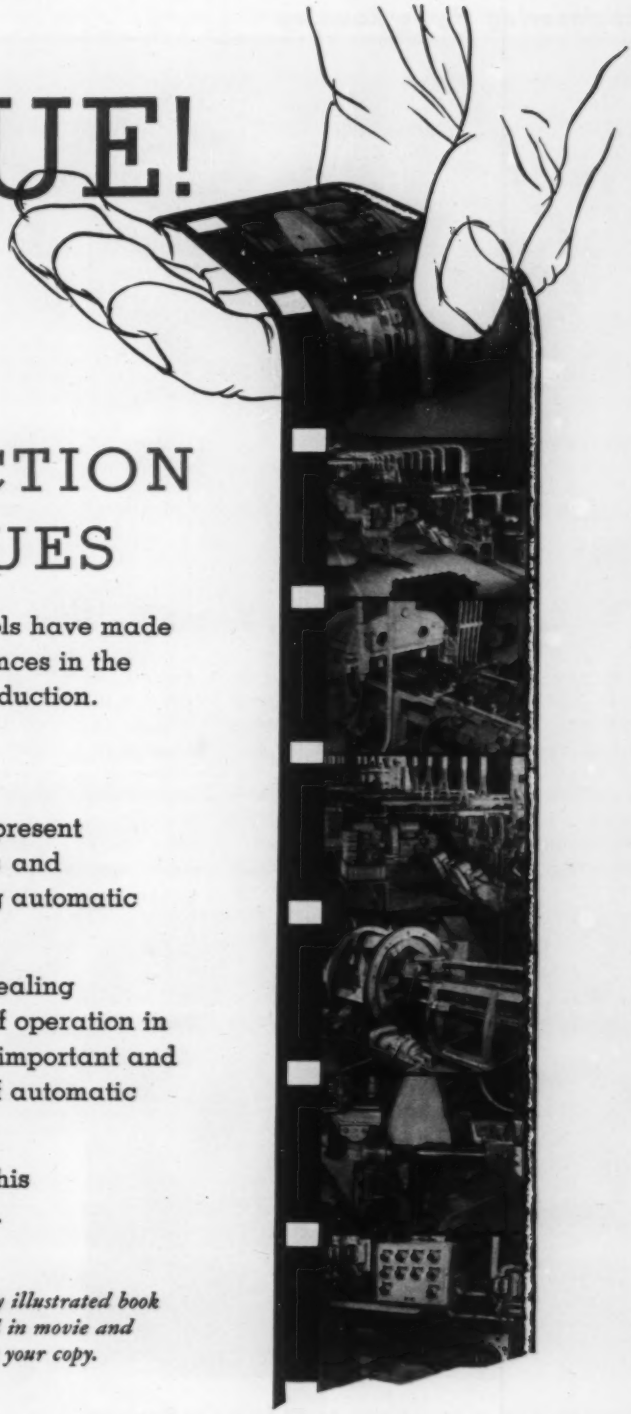
The planning committee is composed of industry members and representatives of the sponsors. Planning cochairmen are A. S. Hall of Purdue and Benjamin L. Hummel of MACHINE DESIGN.



STAMPED ALUMINUM auto hood and rear deck panels perform structural and decorative functions. Reynolds Metals Co. suggests such use of aluminum as a design idea to integrate body components. Ornamental ribs, emblems, moldings and nameplates would be anodized; remainder of the surface would be painted.

UNIQUE!

AUTOMATIC MASS PRODUCTION TECHNIQUES



Barnes hydraulic controls have made possible revolutionary advances in the science of automatic mass production.

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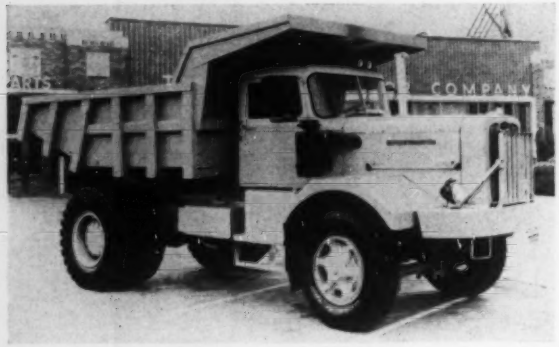
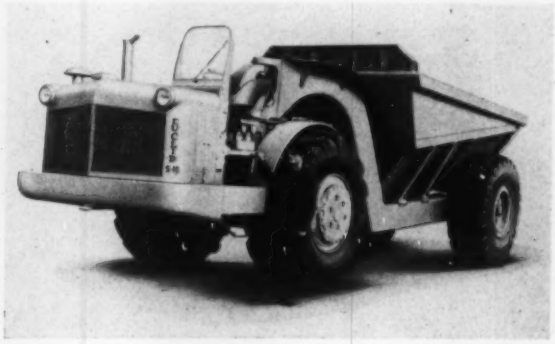


General-purpose off-highway bulk carrier, Autocar model AP-15, has 10 cu yd scoop-end rock body, hauls 15 tons at 39 mph. Double-acting hydraulic hoist provides 70-degree dumping angle. Featured is a planetary gear drive rear axle in which speed reduction occurs at each of the axle ends.



Four-wheel scraper, Euclid model S-18, receives 18 cu yd in scraper-bottom body, travels 20 mph with full load. Recent improvements provide more power in low speed ranges. The S-18 has planetary drive axle and hydraulic action for bowl, apron and ejector. Similar SS-18 model has four-wheel tractor.

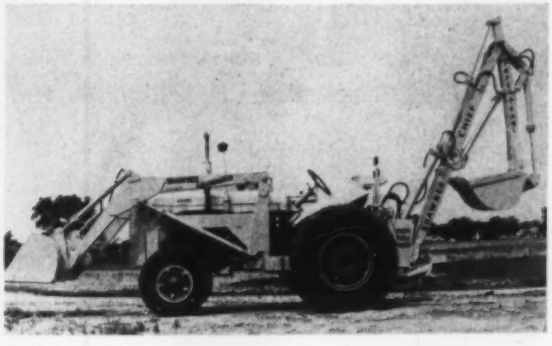
Capacity, Portability, Versatility Mark Products at Biggest Road Show

CHICAGO, ILL.—Road rollers with let-down pneumatic tires and entire paving material plants on wheels illustrate the roadability and portability featured in many lines of heavy equipment displayed recently at this country's biggest Road Show. In Chicago's International Amphitheater, nearly 300 manufacturers worked with the American Road Builders' Association to exhibit modern products for earth moving, road building and highway maintenance. Greater size assortments in many lines and more versatility in multipurpose equipment were also evident.

These are the machines that will soon move mountains to carry out this country's most ambitious road building program. In the next 13 years, $31.5-billion will be spent under the Federal Highway Act of 1956 to produce a new 41,000-mile Interstate Highway System. States to benefit will bear one-tenth the cost. As the Road Show opened, the highway program was already under way. A new section of U.S. 40 was being completed in Kansas near the country's geographic center.

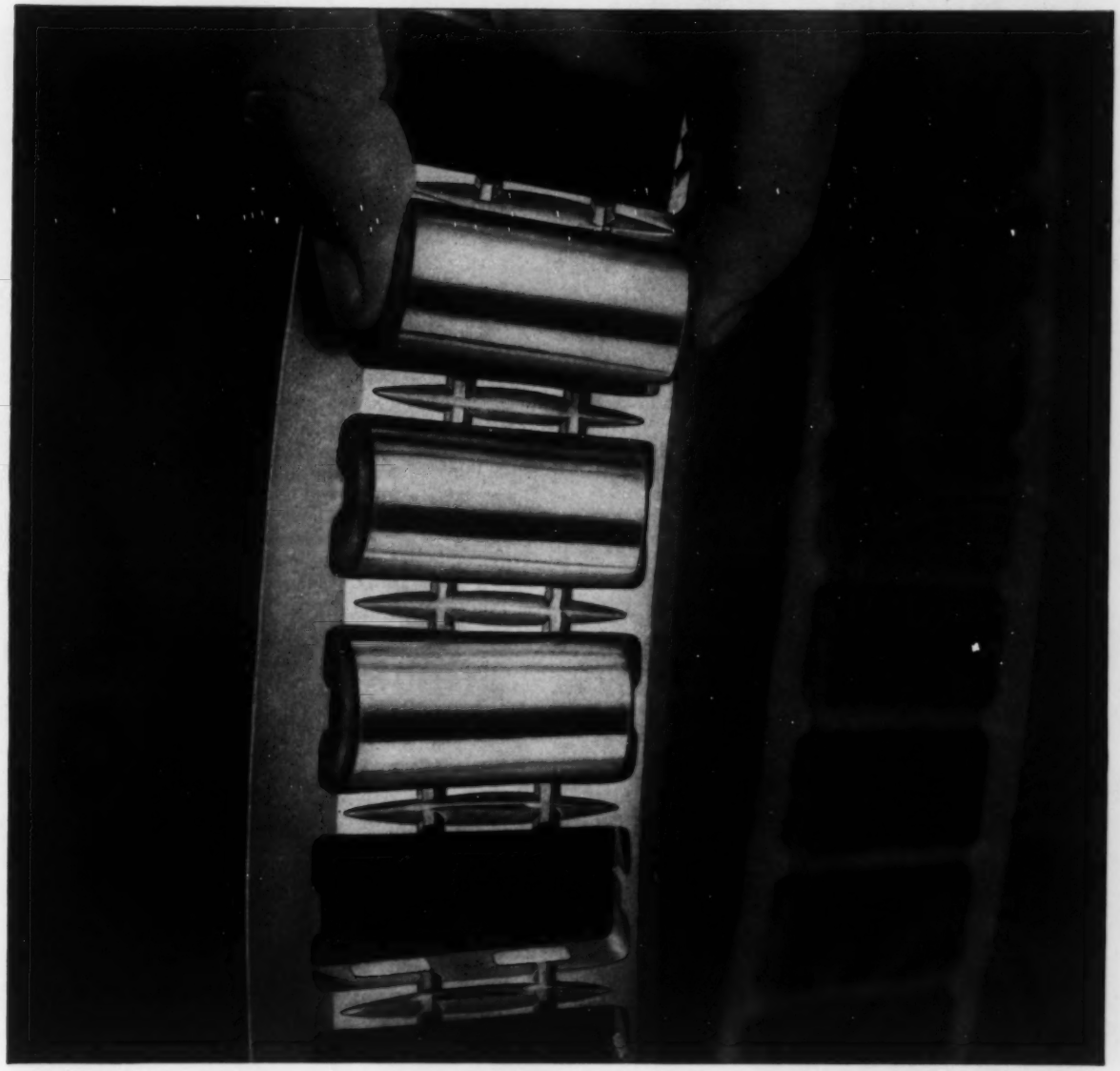
Show exhibitors displayed a variety of equipment scaled to the size of any job. True to the show theme, Pioneer Engineering Works displayed a section of road laid by its paving equipment in Iowa and shipped to Chicago in 4 by 5-ft slabs. To speed the management of road construction, Beech Aircraft Corp. of-

Operating like a human arm, Speed Swing by Pettibone Mulliken Corp. features versatility, is equally adept at earth moving and materials handling. In addition to the bucket shown, Speed Swing can be fitted with snow bucket, forks, crane hook or 18-ft boom extension. Boom swings 180 degrees. Truck has four-wheel drive, three speeds forward, three reverse, can be supplied with four-wheel steering. Speed Swing is claimed the only vehicle able to move earth beyond its tire span.



Conversion kit, by Shawnee Mfg. Co., makes conventional tractor a combination shovel and loader. Hydraulically, it braces feet in rear to enable backhoe to reach 14 ft below ground level and almost 17 ft horizontally from swing axis. Boom swings through three 120-degree quadrants in overall arc of 170 degrees.

TORRINGTON *TAPERED ROLLER* BEARINGS



Accurately caged... to cut your costs!

The one-piece, cast-bronze cage you see above is one of the reasons why TORRINGTON Roller Bearings give long, low-cost service. Note the individual roller retainment, for example. This helps keep the rollers thoroughly lubricated at all times. Race surface inspection is simplified. The machined pads in each roller pocket make sure the rollers are guided accurately at the pitch line. All this to minimize wear... lengthen bearing life.

Yes, TORRINGTON Roller Bearings cut your costs. They're made of the finest bearing quality steel available, heat treated by the most modern methods. No wonder they're so rugged... so dependable. Specify TORRINGTON *Tapered* or *Cylindrical* Roller Bearings for heavy loads and low maintenance.

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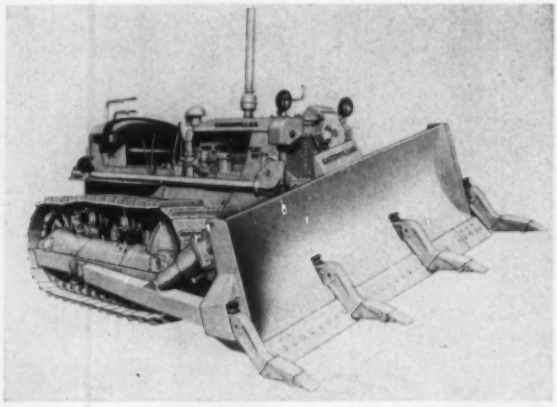
TORRINGTON BEARINGS
Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

Circle 409 on page 19

Firming ground or any loose material in minimum time is the job of the Kompactor, model K-45, by Buffalo-Springfield Roller Co. Its four wheels are faced with staggered rows of steel pads which supply 580 lb per in. of face. The pads enter earth with a minimum of displacement forward or sideways, then leave without disturbing compacted area. This construction prevents loose material from flowing ahead of wheels.



Combination blade, called Gyro Dozer, on a Caterpiller D7 tractor performs ripping and earth moving at the same time. Four teeth, extending 20 in. in front of blade, break up stubborn material to facilitate handling with full width of blade. Penetration angle of teeth and tilt angle of entire blade can be varied by operator for work in woods or on the sides of hills.

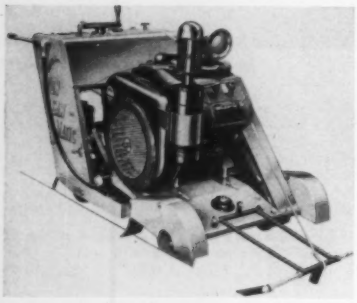
fered its line of business airplanes. Marine construction was represented by the Dixie Dredge, transportable on highways, shown by Service Machinery Corp.

Other products, recently new or improved, were:

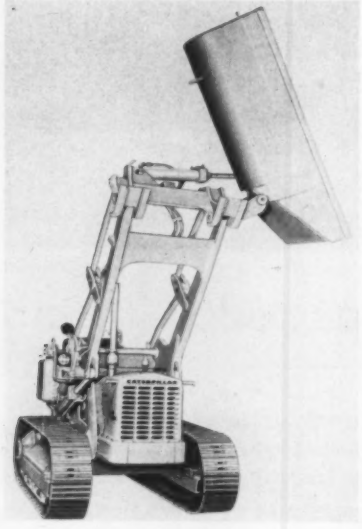
Pneumatic-tired compactor, Chester Products Co. model 13W80, a pull-type roller with 13 wheels which oscillate to cover 95-in. path evenly at 2000 lb per wheel.

Self-propelled, 10-cu yd capacity Cobrette scraper by Wooldridge Mfg. Div. featuring a Torquematic transmission, torque converter and tubeless tires.

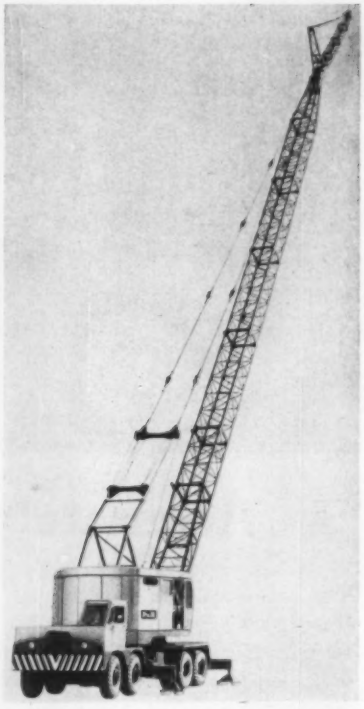
Foundation borer, by Gar Wood Industries, capable of boring a variety of hole shapes up to 25 ft deep, 3 ft in diameter.



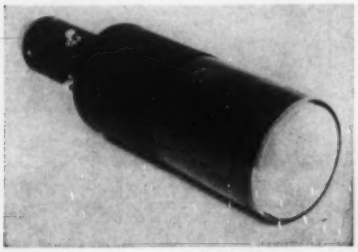
Self-propelled concrete saw, Clipper 36-hp model C-360, features automatically retractable turning wheels. Dual caster wheels automatically take machine load when blade is raised from cut. During sawing, vehicle rolls on four rubber-tired wheels and is driven by abrasive-coated traction wheels.



Side-dumping bucket attachment, for Caterpillar Traxcavators, reduces vehicle maneuvers in digging and loading. A hydraulic cylinder on bucket carriage tilts bucket. Maximum side-dumping angle is 60 degrees. Bucket lip enables material to reach center of 8-ft truck body.



Over-the-highway use is intended for new Harnischfeger model 575-TC truck crane rated 45 tons at 15 ft radius. Longest beam is 170 ft. Four axles distribute truck weight of 96,000 lb, reducible for highway travel to 70,000 lb. Power plant for both truck and crane is 180-hp P&H diesel. Both rear axles drive.



FASTER THAN THE SPEED OF LIGHT, screen patterns are recorded on this Du Mont cathode-ray tube, which permits study of instantaneous physical changes of matter during nuclear bombardment. For typical operating conditions, post-accelerator voltage is 30,000 v and accelerator voltage is 7500 v. At these voltages the tube offers deflection sensitivities of 225 to 270 v dc per in. on X-axis and 155 to 190 v dc per in. on Y-axis.

Ultrasmall Metal Areas Now Analyzed with X-Rays

MONROEVILLE, PA.—A new metallurgical research technique, called point probe analysis, now permits analysis of steel-specimen areas 10,000 times smaller than possible by any other method. The new technique is being developed and refined by scientists at U.S. Steel's Fundamental Research Center.

Eventually, point probe analysis should improve substantially the proper use of metals and the fabrication of structures. In metallurgical investigations, the method is used for the study of inter-granular corrosion, analysis of segregation of alloying elements, measurement of inter-diffusion during welding and plating, and for determining the composition of fine precipitate particles.

The point probe method involves the use of an electron microscope containing a focused electron beam to excite X-ray emission from a region as small as a few microns in diameter.

The basic instrument in the U.S. Steel development is a 7½-ft vertical electron microscope with a 4-ft electron column. Steel samples to be studied are placed in a specimen chamber through a door in the base of the column. A vacuum

(*Continued on Page* 22)

DRAFTING TRENDS

A good cameraman is one key to making high quality cloth reproductions.

Cloth reproductions safeguard originals, save drafting time

Many priceless original drawings are subjected to constant punishment. Corners become dog-eared (from filing and handling) and base stock is abused through repeated erasures when elements must be redrawn. In addition, drawings are prematurely aged and discolored as they go through a reproduction machine time after time.

An increasing number of plants are turning to reproductions on durable cloth stock to protect original drawings. The cloth repro is actually a "duplicate original." It can be repeatedly erased, corrected, intensified, redrawn, used for further printmaking. Negatives can be assembled with sections from other drawings. Expensive original drawings can thus be permanently and safely stored.

How photography improves worn original drawings

Since one method of producing a cloth reproduction is via photography, good camera work improves original drawings in several ways. Weak, fuzzy lines are intensified. Differences in strength of lines are often equalized. Faded or weak areas can be strengthened.

Even *after* an original drawing has been photographed, it can still be improved. A good retoucher can bring back parts of the original drawing. Background smudges or tape marks can be blocked out to give good, clear, clean prints.

By using photographic techniques, cloth repros can be *better than the original.*

Cloth repros simplify enlarging, reducing

Photographic enlargement or reduction to scale eliminates much routine work. By turning details over to the camera and an experienced staff, draftsmen are released for more important layout and design work. Often in a matter of one or two days, you can have a drawing enlarged or reduced to the desired size on a cloth base *without losing valuable drafting time.*

More information on cloth reproductions and a sample print are available from the Reader Service Division of the Frederick Post Company, 3652 N. Avondale, Chicago 18, Illinois.

POST

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MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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Reader Information Service

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USE A YELLOW CARD *for More Information . . .*

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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MACHINE DESIGN
MAR. 7, 1957

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401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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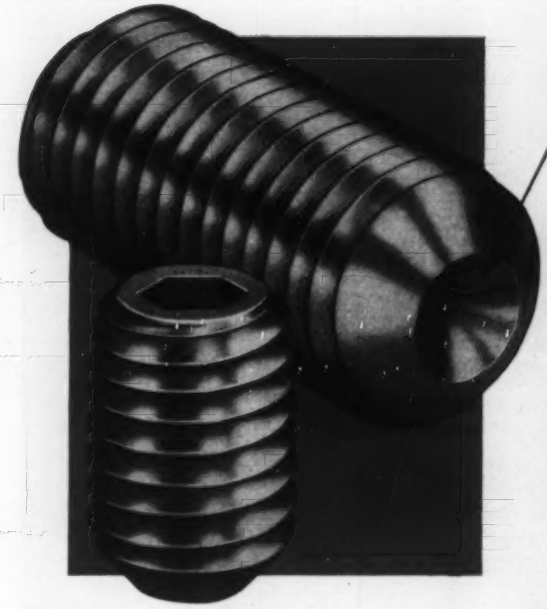


ALLENPOINT will give you a bulldog grip at no premium in price!

Allen's scientific redesign of the cup diameter on set screws gives greatly increased resistance to *withdrawal* torque. You can count on Allenpoint Set Screws to stay tighter longer, under heavy strain and vibrations. This dependable premium performance of Allenpoints is yours to use without increasing the cost of manufacturing your products.

Uniform Class 3A Threads

Allenpoints' smooth, uniform threads prevent off-lead conditions like Fig. 1. With Allenpoints, you have full, even contact between the engaging flanks of the threaded members (Fig. 2) —and a tight friction lock over the entire length of the Allenpoint Set Screw.

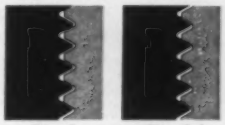


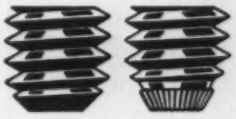
Fig. 1 Fig. 2

Strong, clean, deep sockets allow full wrenching leverage

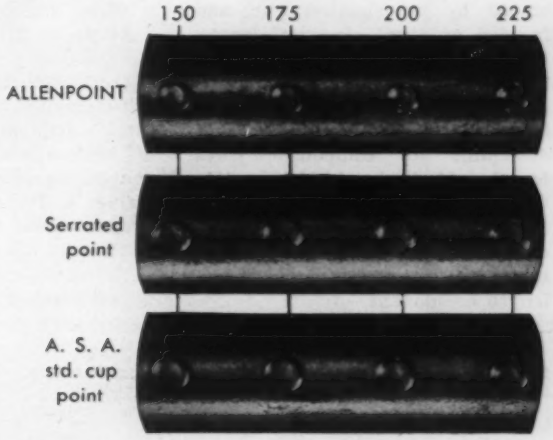
Sockets of Allenpoint Set Screws are cold forged to produce a deeper, smoother socket. No broach chips to interfere with proper seating of the key. This "pressur-forming" preserves the long steel fibers throughout the length of the screw—stronger walls allow maximum tightening torque.

One more full thread on ALLENPOINTS!

Allenpoint Set Screws have one more full thread than serrated point set screws. That means more holding power—especially important when you're using short lengths.



ALLENPOINT's performance compared for you



These actual-size, unretouched photographs show the cup pattern made by Allenpoints, serrated points, and A.S.A. standard cup point set screws in a 3/4" steel shaft. At each degree of tightening force, Allenpoints make a full circle pattern, penetrating deeper for greater holding power.

We'll be glad to send you more information and samples of Allenpoint Set Screws and other Allen Socket Screw products.

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEAD HEX-SOCKET SCREWS

ELECTROHYDRAULIC STEERING system makes the new river towboat *Cypress* possibly the most maneuverable of its type in service today. *Cypress* is the first commercial vessel to carry this kind of equipment developed by Sperry Gyroscope Co. Pilot-house lever operates a 15-hp motor which drives a variable delivery pump. Pressure from the pump operates rams which move the rudders through 80 degrees in 10 seconds. Normally, the system operates flanking rudders, can also operate auxiliary main rudder.

(*Continued from Page* 15)

is then created by a standard oil-diffusion pump. The beam is generated by an electron gun and focused by three electrical lenses.

The focused beam strikes a selected area of the specimen's surface, causing X-ray emission. The beam emitted is then analyzed to determine its component wave lengths. Each chemical element in the sample emits an X-ray of characteristic wave length. The concentration of an element determines the intensity of its wavelength component.

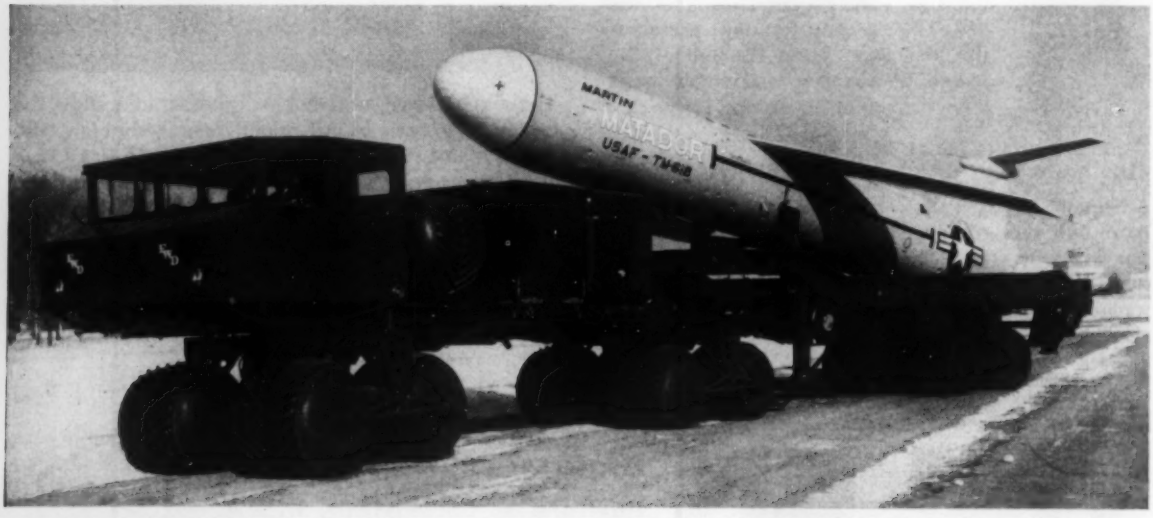
Trucks with Baggy Tires Launch Matador Almost Anywhere

Missile Carrier Operates At Speed Off Highways

WASHINGTON, D. C. — Completely self-contained vehicles now carry the Matador guided missile to sites off highways and launch the weapon on its mission. The vehicles include a Teracruzer truck and a Translauncher trailer. Both truck and trailer are air-transportable in C-130 and larger aircraft. Both obtain cross-country mobility from Terra-Tires which look like rubber barrels and carry only 3 to 15 psi air pressure. Currently, the cargo for the transport pair is the second model Matador, designated TM-61B.

The Martin Co. is the builder of the Matador and prime contractor of the entire missile system. Four Wheel Drive Auto Co. developed the Teracruzer and Goodyear Aircraft Corp. provided the Translauncher.

The Terra-Tires are made by Aviation Products Div. of Goodyear Tire and Rubber Co. Each is 3 1/3 ft long and 3½ ft. wide. Their shape and low pressure enable the

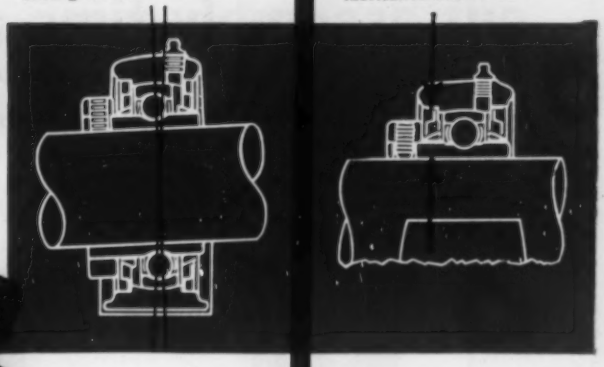


Matador missile vehicles include a Terracruzer truck, prime mover for the assembly, and Translauncher semi-trailer which carries the missile and its launcher. Truck and trailer ride on bag-like Terra-Tires which carry 3 to 15 psi air pressure and enable off-highway travel to launching sites, even through snow and mud.

Self-aligning SEAL AND ALL

SELF-ALIGNMENT is assured because the lubricated, spherical outer ring is free to align in any direction. Full load capacity is always maintained regardless of shaft deflection or misalignment.

POSITIVE PROTECTION of the rolling elements from moisture, dust and dirt is provided by self-aligning seals extending from housing to inner ring. Large grease reservoir prolongs lubrication intervals.



Series 200 and 300 ball bearings

That's why grease stays in, dirt out of these LINK-BELT ball bearings

To compensate for supports and shafts that misalign in service . . . for unavoidable inaccuracies in mounting—Link-Belt offers self-alignment in ball bearings. And to protect that vital feature against dust and dirt, Link-Belt provides effective seals that *align along with rolling elements.*

Self-alignment is standard throughout industry's most complete line of ball and roller bearings—pillow blocks and flange, flange cartridge, cartridge and take-up units. Ask any one of 40 Link-Belt offices for Book 2550.

14,330-A

LINK BELT

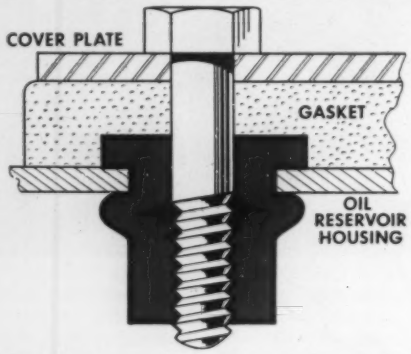
self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

Circle 413 on page 19

B.F.Goodrich Rivnuts

cut assembly time and costs by 50%



ELIMINATE WELDING, TAPPING AND CLEANING

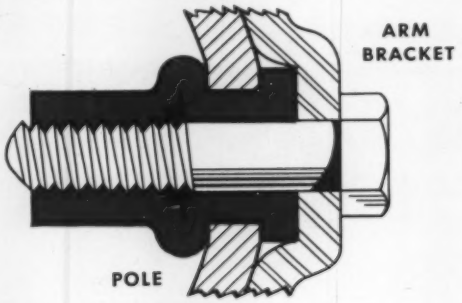
A fastening job on oil reservoir housings formerly took 5 operations. First the housings had to be detoured from the assembly line. Then nutplates were welded on the inside, drilled, tapped and cleaned before the covers could be attached.

By switching to B. F. Goodrich Rivnuts, this whole job is now done in half the time. Rivnuts are installed by one man from one side, in seconds. They provide firm, accurate nutplates with six clean threads for fastening. Flow of assembly is uninterrupted.

ONE MAN NOW DOES THE WORK OF TWO

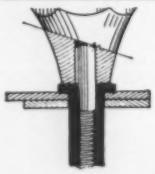
Using conventional nuts and bolts, it took two men to fasten the arm bracket on street light poles. Now, with B. F. Goodrich Rivnuts, one man does this work in the same amount of time.

In the factory, one worker installs Rivnuts in the aluminum poles simply, quickly. The assembler in the field merely lines up the brackets, slips the attachment bolts into position and tightens them. As for strength, tests show that the pole or arm bracket will fail before the Rivnuts.

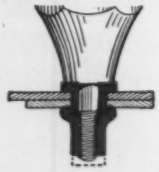


Rivnuts provide at least 6 clean threads in one simple operation!

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work — tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact ready for screw attachment.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to *B. F. Goodrich Rivnuts, Department MD-37. Akron, Ohio.*

B.F.Goodrich

AVIATION PRODUCTS

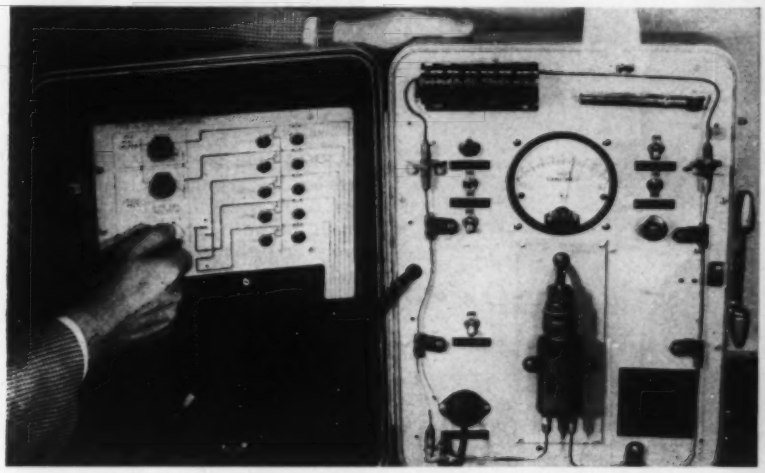
a division of The B. F. Goodrich Company, Akron, Ohio

vehicles to traverse deep snow, sand, swamp, mud and boulder-strewn areas.

In addition to towing the Translauncher and missile, the Teracruzer carries the missile nose, booster and fuel. It also carries power equipment for handling, testing, and launching the missile. Teracruzer is powered by an eight-cylinder, 250-hp, Continental air-cooled engine inside the cab.

Loaded with 8 tons of missile support equipment, the Teracruzer can travel 40 mph on highways and 25 mph cross-country. Earlier models of the Teracruzer have been built, but this version is the first on which drive power has been applied directly to axles of all tires.

At the launching site, the Matador is aimed and elevated while still on the Translauncher, then started on its course by a booster rocket. When the booster's fuel is expended, the booster drops off and the Matador continues under power from its own jet engine. Top speed is more than 650 mph. The TM-61B is 5 ft longer than the original Matador, has increased range, more powerful engine and improved guidance. It also has folding wings which enable faster missile assembly at the firing site.



Portable conflagration is generated in a test kit to demonstrate the operation of a new discrete fire warning system. Warning is given at definite temperature setting regardless of ambient temperature.

Warning System Senses Equal Intensity Fires

Temperature Alone Triggers Device

NEW YORK, N. Y.—A temperature-sensing element based on inorganic salts and an amplifier containing no tubes, transistors, relays or other moving parts are featured components of a new continuous fire detection system for aircraft. Properties claimed for the Fenwal Inc. system are discrete sensing at a predictable temperature regardless of the length of detector exposed, virtual elimination of "averaging," and adaptability to high service temperatures. In addition, Fenwal believes the system will substantially reduce false alarms and will require considerably less maintenance and component replacement than present continuous systems.

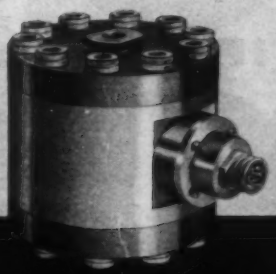
The temperature sensing element in the new system is installed as a continuous cable around or through the protected zone. The magnetic amplifier control unit is connected to the detector loop and senses electrical changes in the detector when an overtemperature condition occurs. The output of the control unit operates alarm lights and, when desired, an auxil-

MODELS PL80 AND PM80

Differential Pressure Transducers

FOR

flow measurement



AT

Rocket Engine Stands
Hydraulic System Tests
Nuclear Reactors

the flow of liquids and gases is being measured by connecting Model PL80 and Model PM80 pressure transducers across an orifice.

Ranges
±1 to ±3000 psid and 0-1 to 0-3000 psid

Line Pressure Rating
5000 psig

Pressure Media
Fluids not corrosive to Types 303 and 347 stainless steel

Transduction
Resistive, Statham unbonded strain gage

For additional data, please request Bulletin Nos. PL80TC and PM80TC

Statham
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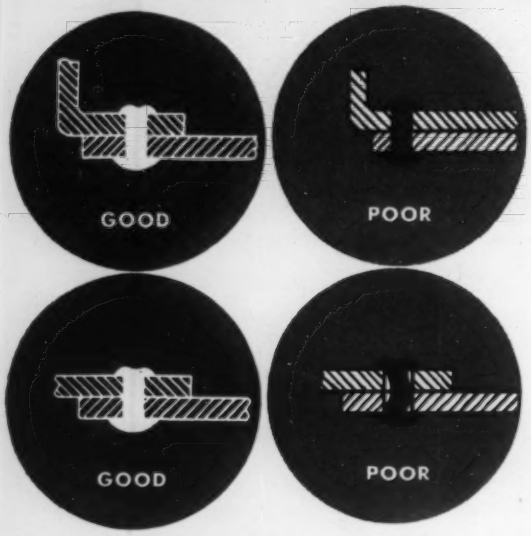
Circle 415 on page 19

TIPS ON USING RIVETS



A short design course guaranteed to save a lot of grief later on!

You could memorize these and thousands more design tips on the best use of rivets—but don't! Much simpler to call on Milford for the right answers to all your riveting design and application problems. Full-tubular, semi-tubular, split, cutlery, decorative—Milford makes them all from any metal that can be cold-formed, then adds a wide variety of platings and finishes.

To improve product appearance and strength
. . . to take full advantage of automatic assembly
. . . to cut delivery time and production costs
—get in touch with Milford first!

THE MILFORD RIVET

MILFORD RIVET & MACHINE CO.

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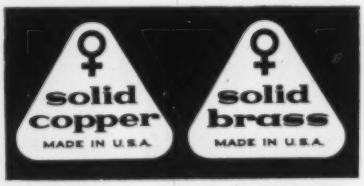
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

iary relay to actuate other warning or emergency devices.

The detector can be shaped by hand to avoid obstructions and will follow contours no larger than a pencil diameter. Up to 100 ft of detector can be served by one control unit. The connected system forms its own electrical circuit and requires no separate wiring except that needed for auxiliary equipment.

The detector element consists of a seamless tube with a nickel wire conductor running through its center. A mixture of specially-developed inorganic salts acts as insulation between the inner wire and outer tube. During normal monitoring operation the center wire carries a low-voltage ac current impressed on it by the control unit which is connected to the aircraft electrical system. When an over-temperature condition occurs, resistance of the salt filler drops sharply, permitting a large increase of current between the inner wire and outer tube. This current change is sensed by the control unit which produces the output signal to actuate the warning circuit.

Other continuous detector systems also employ the temperature-resistance properties of a filler material, usually a semiconductor. In these systems, the circuit resistance is governed both by the temperature and by the length of detector exposed to the temperature. The greater the length of detector exposed to a given temperature,



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the lower will be the circuit resistance. This effect is called "averaging." It permits a system to trigger at ambient temperatures appreciably lower than the alarm temperature, that is, to false alarm.

The salt in the Fenwal detector undergoes a several hundred-fold more rapid drop in resistance at the alarm temperature. Relatively small temperature differences produce large resistance differentials, so that there is a significantly large difference in resistance between adjacent points not at the same temperature. The detector is therefore capable of discrete sensing, practically free of averaging effects. Response temperature will be within 10 degrees for sections of any length between 20 ft and ⅛-in.

Fixed temperature sensitivity regardless of the length of detector exposed has several advantages. It assures equally rapid response to both a wide-spread fire and a localized hot spot; the detector can be installed at temperatures close to the alarm point without risking false alarms; and it enables tailored protection for zones having different ambient temperatures.

Ductile Alloy Rivals 18-8 Cast Stainless

COLUMBUS, O.—Better mechanical properties than the usual 18-8 stainless steel and no significant difference in corrosion resistance are features of a new high-strength cast alloy recently announced by the Alloy Casting Institute. Designated type CD-4MCu, the alloy has the following composition: 25 to 27 chromium, 4.75 to 6.00 nickel, 0.04 max carbon, 1.75 to 2.25 molybdenum, 2.75 to 3.25 copper, 1 silicon and 1 max manganese.

In boiling 65 per cent nitric acid, corrosion rates of the new CD-4MCu cast stainless alloy are about the same as 18-8 stainless. Elongation and reduction of area values for the new alloy reveal its high ductility, even at hardness of approximately 300 brinell, tensile strength of 140,000 psi, and yield

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The ONLY Line that offers You Several Distinct Types of filter Media . . . The RIGHT Choice for Every Requirement

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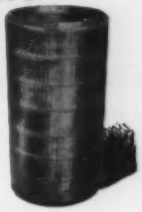
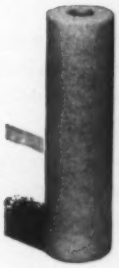
METAL EDGE TYPE
Continuously cleanable. Combine small size, high flow rates and low pressure drop. A wide range of models and sizes with capacities to 4000 gpm and filtrations as fine as 40 microns.

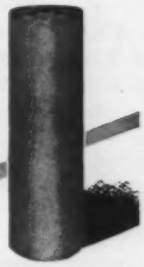
FLO-KLEAN
WIRE-WOUND
For low-viscosity, high volume (up to 15,000 gpm) filtration. Filtration from .0025" to .030". Filters are completely automatic, continuously self-cleaning without loss of backwash fluid.



MICRO-KLEAN
FIBER CARTRIDGE
New white cellulose cartridge for 5-micron filtration wherever clarity, purity and taste are essential. Wool cartridge for a wide range of 10 to 70 micron applications including compressed air. Housings for flow rates from a few gph to hundreds per minute.



PORO-KLEAN
POROUS STAINLESS STEEL
Cartridges and special forms. Combine extreme heat and corrosion resistance, high tensile strength and very fine filtration (down to 5 microns, standard). Tests prove no contamination from particle discharge.



*Because no *one* type of filter is best for every need, Cuno — and *only* Cuno — offers you a truly complete line that includes *several* distinct types of filtration media. And because every filtration system must be specified and engineered to the individual job requirements, Cuno also offers you a complete application engineering service through the Cuno Systems Engineer. Conveniently located in your area, one of these specialists is ready and qualified to help select the filter type and model exactly right to solve your problems.

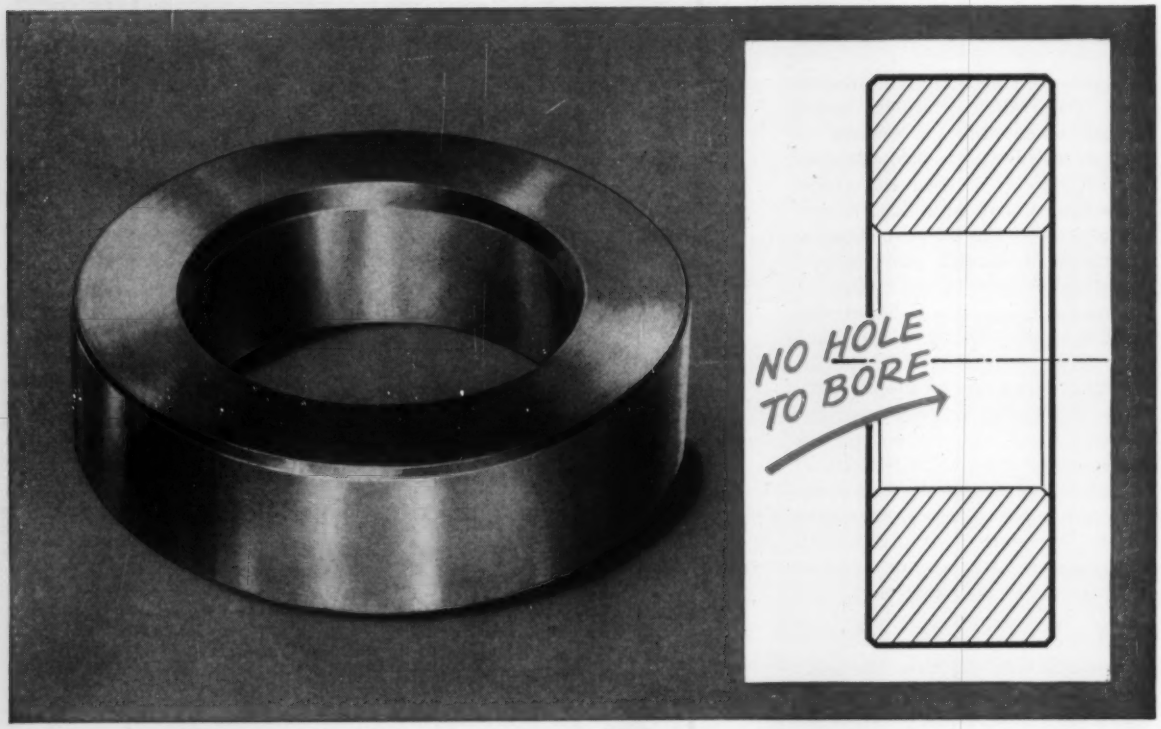
SEND FOR FREE PRODUCT LITERATURE

CUNO ENGINEERING CORPORATION
1403 SOUTH VINE STREET, MERIDEN, CONNECTICUT
TELEPHONE: BEverly 7-5541

EDGE-TYPE, WIRE-WOUND, FIBER CARTRIDGE and POROUS METAL FILTERS

Filtration Engineers in Principal Cities

Circle 417 on page 19



Steps up gear blank production 300% by switching from bar stock to TIMKEN® steel tubing

AN engine manufacturer felt that his gear blanks were costing him too much to make. The center hole had to be bored out of solid bar stock. It took a whole hour to turn out 29 blanks. And a lot of steel was wasted in the process.

So the manufacturer discussed his problem with metallurgists of the Timken Company, experts in fine alloy steel. After study they recommended a change in production methods together with a switch to Timken® seamless steel tubing in place of bar stock.

With Timken seamless steel tubing, the center hole is already there. It doesn't have to be bored out. Finish boring was the engine maker's first production step. And with Timken steel tubing his gear blanks are now being turned out at 120 to 130 an hour—an increase of 300%.

Machining costs have been cut by more than half. And because the center hole is "built-in", no steel is wasted.

The files of the Timken Company contain records of hundreds of problems that have been solved by Timken fine alloy steel. If you have a tough steel problem, why not bring it to us? Wire, write or phone The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U. S. PAT. OFF.

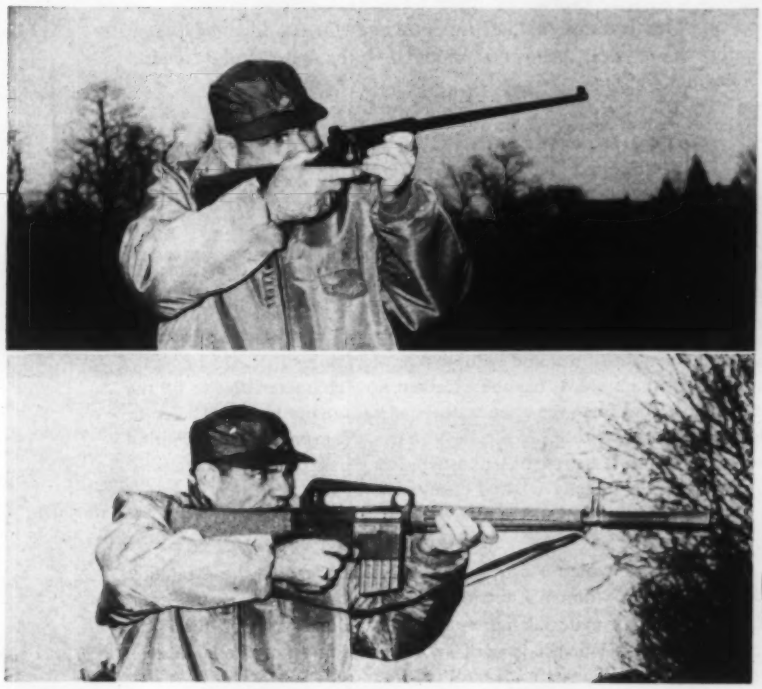
SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Circle 418 on page 19

strength of 100,000 psi. Corresponding properties of comparable 18-8 alloys would be 150 brinell, 77,000 psi tensile, and 37,000 psi yield, respectively.

Not only is the corrosion rate of the new alloy in boiling nitric acid very low, but there is no tendency for the corrosion rate to increase with time. Corrosion resistance has been confirmed by Strauss tests which consist of bending the specimens after exposure to a boiling, copper sulfate, sulfuric acid solution. No decrease in angle of bend before cracking has been observed after exposure to the Strauss solution for 72 hr. The new alloy has shown no corrosion at room temperature in 10 per cent sulfuric acid, 50 per cent sulfuric acid, or 0.5 per cent hydrochloric acid. Even in 5 per cent hydrochloric acid the corrosion rate is only 60 mils per year.

The new alloy is reported to have better machinability than 18-8 stainless, good welding and grinding characteristics, and good foundry characteristics, including fluidity and feeding. Castings of the new alloy can be obtained from members of the Alloy Casting Institute.



New Air Force survival weapon, MA-1, above, and proposed automatic rifle, AR-10, below, feature light weight, simple field disassembly and corrosion-resistant materials. Both are made by Armalite Div. of Fairchild Engine and Airplane Corp. and are shown tested by R. S. Boutelle, Fairchild president.

Light Weapons to Ease Burden Of Infantry, Downed Airmen

USAF Survival Rifle Floats in Water

HAGERSTOWN, MD. — Lightweight materials, simplicity of disassembly, and compactness in kit form distinguish a new Air Force survival weapon developed by the Armalite Div. of Fairchild Engine and Airplane Corp. The same properties and versatility of employment are characteristics of a Fairchild automatic rifle currently being compared with standard Army infantry weapons. Both new rifles have aluminum barrels with stainless

(*Continued on Page* 32)

Why wrestle with GEAR PROBLEMS?

Get the right solution from SIER-BATH

Instead of "try this" and "try that" suggestions, Sier-Bath provides the seasoned experience of gear experts who immediately recognize and solve your problem the *first time.* You save time—and get better gears that cost you less.

Sier-Bath customers enjoy the best gear design, engineering and manufacturing service. Many machine manufacturers have moved to leadership in their fields, through the improved operation of Sier-Bath gears.

Send us your gear drawings for study and quotation—or have a Sier-Bath gear specialist call to discuss your gear requirements.

FREE! Valuable 36-Page Gear Manual

This authoritative manual brings you the most advanced gear technology, design data and complete specifications of what to demand in gears. Clearly illustrated with photos, graphs, tables and technical views. Write on company letterhead for your free copy.

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Established 1905 Member A.G.M.A.
Also Manufacturers of Rotary Pumps and Flexible Gear Couplings

Sier-Bath PRECISION GEARS

All kinds of gears—all materials.
Made—cut—shaved—ground tooth.
48" maximum diameter

Circle 419 on page 19

Craftsmanship of the 20th Century

MONSANTO

Speeding the development of many new products is the availability of a wide range of plastic materials with highly usable combinations of properties. In the creative hands of custom molders, these plastics are translating manufacturers' plans and ideas into highly serviceable finished products. Read how one of America's foremost electrical manufacturers teamed with a custom molder to produce an unusually efficient and attractive louver-diffuser.

Lustrex styrene plastic and the sight-saving secret of the new Guth Gratelite

DESIGN OBJECTIVES. To design a shadowless lighting system providing comfortable diffusion, low brightness and efficient illumination, yet possessing the physical shallowness required by the architectural trend to lower ceilings.

MATERIAL SPECIFICATIONS. The "answer," designed by Edwin F. Guth, Sr., was the Guth Gratelite, a translucent plastic grid with ⅜" "sight-saving" cubical openings. The grid sizes: 10⅞" x 48" and 16" x 48". The plastic: Lustrex, Monsanto's styrene. The choice of Lustrex was dictated by many appearance, functional, and production factors which Prolon has skillfully utilized. The spoilage factor in molding Gratelites of Lustrex is unusually low. Lustrex has release properties necessary for molding a multi-ribbed unit without fear of sticking or fracturing upon removal from the mold. It has the excellent flow characteristics to fill the 3,850 sections that form the open squares of a Gratelite louver. The color stability of Lustrex produces the brightness and even light distribution specified by Guth. Lustrex has unusual strength in thin cross sections. Lustrex louvers are easily washed clean without loss of luster; they are rigid, light in weight, warp-resistant.

PRODUCTION. Prolon Plastics, Florence, Mass. molds the Gratelites in 400 oz. Watson-Stillman Injection presses. Good craftsmanship combined with the right materials permits rapid molding cycles on these 48" long louvers. Pre-plasticizer is used and the molding powder is Lustrex Hi-Flow 77.

THE FINISHED PRODUCT. In the past 5 years, hundreds of thousands of Guth Gratelites have been installed in offices, stores, banks, and factories throughout the world. Delicate white in appearance, tough and efficient in operation, these louver-diffusers are contributing to restful illumination wherever they are used.

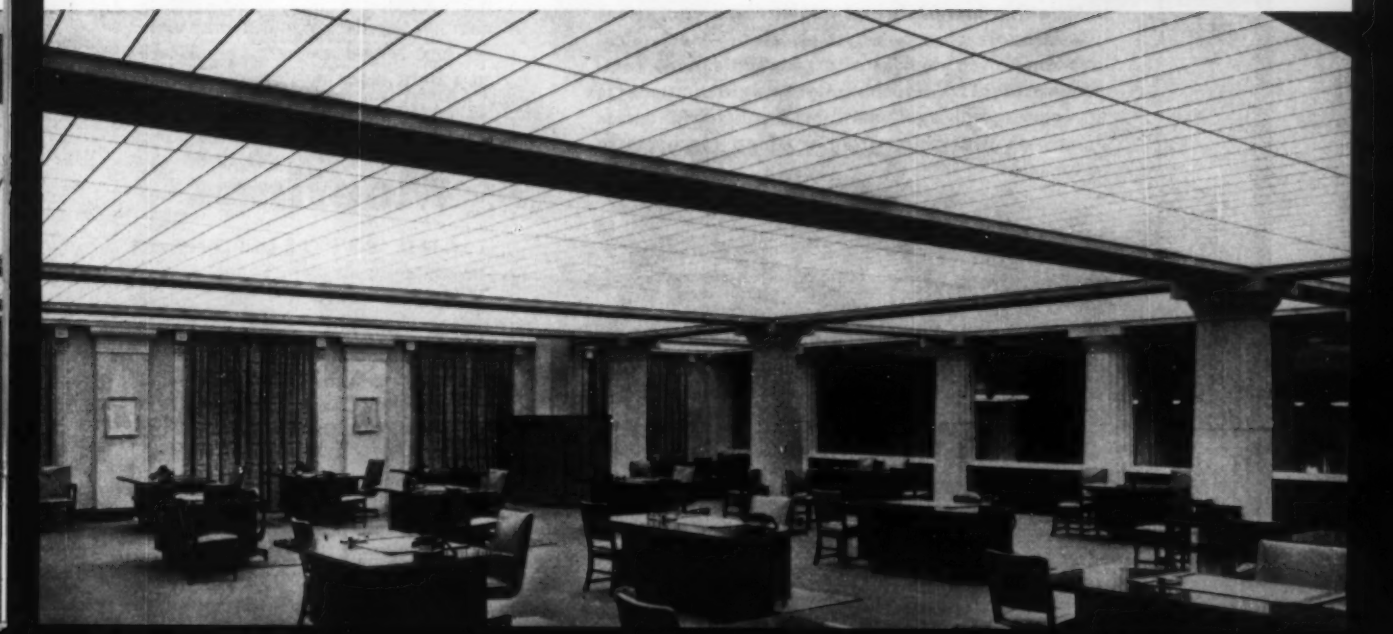
The Gratelite is one of hundreds of design and production problems solved through the utilization of the skills and experience of the plastics custom molding industry. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who are ready to work with you on product development and improvement. Write to Monsanto Chemical Company, Industrial Applications Dept., Rm. 2096 Springfield 2, Mass.

Circle 420 on page 19

Investigate the Monsanto completely-balanced line of styrene plastic compounds developed for particular applications and sold under the trade name . . .

LUSTREX
Styrene Plastic

MONSANTO



CAMLOC *low cost/light weight*

5F series

Camloc's new small, lightweight 5F Series features high strength-weight ratio plus the quick-operating advantages of a ¼-turn fastener... in a size and weight that offers new design possibilities to original equipment manufacturers! Particularly adaptable to thin materials and miniaturized equipment like airborne electronics, small electro-mechanical and computing devices and communications components. Ideal for attaching lightweight components in "packaged" equipment or for holding access panels on everything from washing machines to radar units.

Offered in many different head styles. Complete specifications will be sent to you on request.

CAMLOC®

FASTENER CORPORATION
37 Spring Valley Road, Paramus, N. J.

WEST COAST OFFICE: 5410 WILSHIRE BLVD., LOS ANGELES, CAL.
FORT WORTH OFFICE: 2509 W. BERRY ST., FORT WORTH, TEXAS

News Roundup

(*Continued from Page* 29)

steel liners, aluminum and stainless steel actions, aluminum or stainless steel magazines, glass fiber and plastic foamed stocks.

The survival rifle, assigned Air Force designation MA-1, is 30½ in. long. It has bolt action, uses a four-shot clip, and is equipped with a .22 Hornet barrel. The barrel and action are easily disassembled without tools of any kind and stored inside the stock. This arrangement is a 14-in. package that fits standard Air Force survival kits.

The stock also contains a chamber for compass, matches, needles, fish line and hooks. Assembled or disassembled, the MA-1 will float in water. Its total weight is 2 lb 6 oz, and effective range is 250 yd. Tested useful life is more than 6000 rounds. Civilian models can be supplied in a variety of colors.

The automatic rifle carries Fairchild designation AR-10. It uses the NATO 7.62-mm cartridge and will deliver automatic or semiautomatic fire from 20-round magazines. Rate of automatic fire is adjustable; prototypes operate at 700 rounds per minute. Total weight is 6.85 lb, about the same as the World War II carbine. Overall length is 40.5 in. including muzzle brake and flash suppressor.

The AR-10 can be disassembled with a cartridge as the only tool. At the balance point, it has a carrying handle shaped to protect the rear sight. A winter trigger is part of the design. A heavy barrel and tripod convert the AR-10 to a light machine gun.

Meetings

AND EXPOSITIONS

March 25-27—

American Society of Tool Engineers Silver Anniversary Technical Meeting and Convention to be held at the Shamrock Hilton Hotel, Houston, Tex. Additional information is available from society headquarters, 10700 Puritan Ave.,

Detroit 38, Mich.

March 25-27—

American Management Association. Research and Development Conference to be held at the Palmer House, Chicago. Additional information is available from association headquarters, 1515 Broadway, New York 36, N. Y.

March 25-29—

Tenth Western Metal Exposition and Congress to be held at the Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles. Sponsors are American Society for Metals and other technical groups. Additional information is available from ASM headquarters, 7301 Euclid Ave., Cleveland 3, O.

March 25-29—

American Society for Metals. Biennial Technical Meeting to be held at the Ambassador Hotel, Los Angeles. Additional information is available from society headquarters, 7301 Euclid Ave., Cleveland 3, O.

March 25-29—

Society for Nondestructive Testing. Biennial Technical Meeting to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from society headquarters, Skokie, Ill.

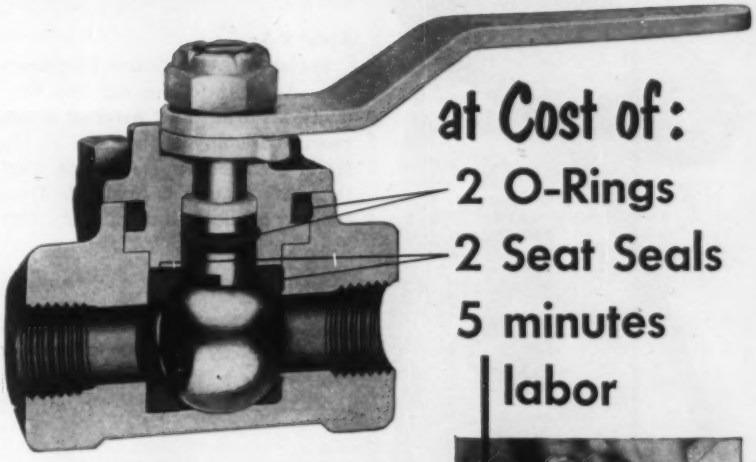
March 27-28—

American Society of Mechanical Engineers-American Institute of Electrical Engineers Engineering Management Conference to be held at the Hotel William Penn, Pittsburgh. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

March 27-29—

American Power Conference, to be held at the Hotel Sherman, Chicago. The conference is sponsored by Illinois Institute of Technology in co-operation with 14 universities and nine national and regional technical societies. Additional information is available from conference secretary E. R. Whitehead, Illinois Institute of

Install "NEW" Valve

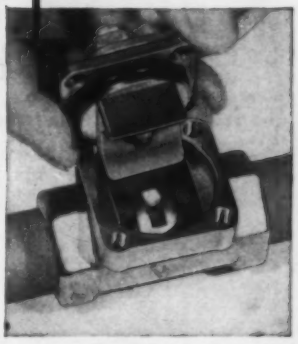


at Cost of:

2 O-Rings

2 Seat Seals

5 minutes labor



That's all it takes for easy TOP ENTRY "in-line" maintenance of Worcester's new TWIN SEAL BALL VALVE.* To replace sealing components, simply remove the four bonnet bolts, and then the bonnet assembly. Ball and seat rings are easily lifted out by using hook in the hole provided in the stem slot. After cleaning seating surfaces in the body, replace ball and new seat rings as a unit. A new O-ring at the bonnet joint and around the stem will assure tight seals at these critical points. Result? . . . "factory tight" sealing properties in your long lasting Worcester TWIN SEAL Ball Valve . . . plus flexibility of seat selection to suit a great variety of media.

*Patents Pending

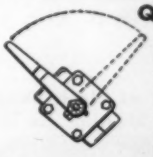
OTHER OUTSTANDING FEATURES

TWO-WAY FLOW

Two-way Flow . . . with positive shut-off . . . will hold nearly perfect vacuum. There is no danger of "wrong way" installation.

With opening in ball and seat rings maintaining same smooth shape as inside of pipe, resistance to flow is well below that of other valves and friction loss is reduced to a minimum.

QUICK OPERATION



The TWIN SEAL Valve goes from fully opened to fully closed position with only a quarter turn of handle and operator knows instantly position of ball and degree of closure. Valve adapts itself readily to remote control and mechanical operation.

FORGED CONSTRUCTION

Lack of porosity, closely held tolerances, absence of stress concentrations and the best possible material flow are some of the advantages of forged construction offered in Worcester's Twin Seal Ball Valve.

This valve is available in naval bronze and aluminum bronze. Seat material may be selected from Buna N, Neoprene, Natural Rubber, Teflon and Kel F allowing this valve to handle Water, Air, Propane, Oxygen, Chemicals and a great variety of other media.

Ball Gate Needle Valves

Write for full particulars

WORCESTER VALVE CO., INC.

18 PARKER ST. • WORCESTER, MASS.

Circle 422 on page 19

Whether you're a production man, plant engineer, designer of original equipment, or a manufacturer looking for ways to reduce costs and overhead—there's a way that real savings can be built into machinery used in your industry!

Reduced down-time and repair bills . . . longer machine life . . . increased production . . . elimination of costly hand oiling, and product spoilage due to over-lubrication are only a few of the benefits derived when a Bijur System becomes your "silent partner." Every bearing gets just the *right* amount of clean oil at the *right* time . . . automatically, while the machine is running.

Learn how inexpensive it is to start saving–the Bijur way. Write today for all the facts! © 1957

P-4

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

Circle 423 on page 19

Engineering News Roundup

Technology, 3300 Federal St., Chicago 16, Ill.

April 2-5—

Society of Automotive Engineers Inc. Aeronautic Meeting and Production Forum and Aircraft Engineering Display to be held at the Hotel Commodore, New York. Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

April 4-5—

American Management Association. Research and Development Conference to be held at the Statler Hotel, New York. Additional information can be obtained from association headquarters, 1515 Broadway, New York 36, N. Y.

"Try a softer lead."

April 7-10—

American Society of Mechanical Engineers. Instruments and Regulators Conference to be held at Northwestern University, Chicago. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

April 8-10—

American Society of Mechanical Engineers. Spring Meeting to be held at the Hotel Dinkler-Tutwiler, Birmingham, Ala. Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

April 8-11—

American Management Association. National Packaging Conference and Exposition to be held at the International Amphitheatre and the Palmer House, Chicago. Additional information can be obtained from association headquarters, 1515 Broadway, New York 36, N. Y.

April 9-11—

American Welding Society. Fifth Welding Show to be held at Convention Hall, Philadelphia. Annual meeting and technical sessions of the AWS will be held at the Hotel Sheraton, April 8-12. Further information can be obtained from society headquarters, 369 Lexington Ave., New York 17, N. Y.

April 15-17—

Symposium on Systems for Information Retrieval to be held at Western Reserve University, Cleveland. Symposium is to be presented by the university's School of Library Science in conjunction with its Center for Documentation and Communication Research.

April 16-17—

American Institute of Mining, Metallurgical and Petroleum Engineers. Conference on High-Temperature Materials to be held at Hotel Carter, Cleveland. Further information is available from institute headquarters, 29 W. 39th St., New York 18, N. Y.

April 25-26—

American Society of Mechanical Engineers—Society for the Advancement of Management. Management Conference to be held at the Statler Hotel, New York. Further information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

May 16-17—

Fourth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

TORRINGTON PRESENTS:

An important new line of complete blower units for central air conditioning, heating and ventilating, in a wide range of sizes, full and three-quarter widths, and incorporating the following exclusive Torrington features:

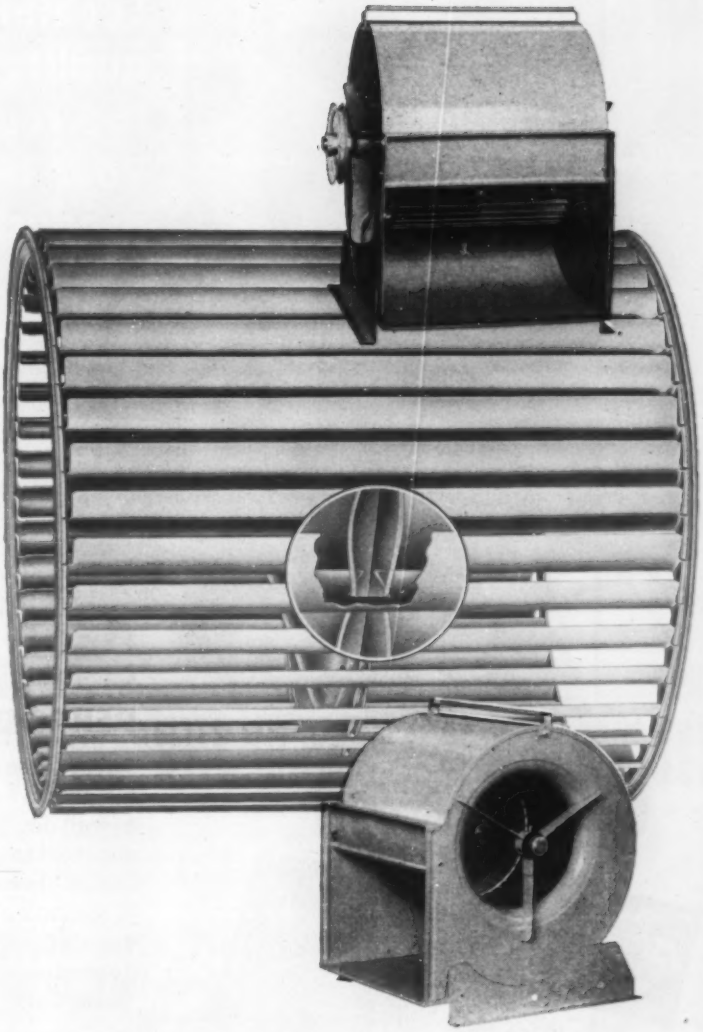
1. An exceptional new Center-Lock airotor introducing an entirely new principle of blower wheel construction in which (see insert) the center disc is dovetailed under pressure into the encircling blades. As a result of this design feature, the interlocking joint *tightens* under centrifugal force, eliminating blade rattle and angle warp at high speeds.

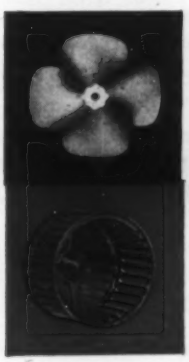
2. A Multi-Position blower housing, easily adaptable to left or right, up or down flow requirements, of the finest welded steel construction and special finish.

3. Availability in either belt-driven or direct drive assemblies.

4. Unit flexibility, providing feet, motor mounting assembly to meet your individual mounting requirements.

This new product line is a major development backed by all the standards of engineering quality consistent with Torrington leadership in the air impeller industry. Your inquiries are invited.





THE
TORRINGTON
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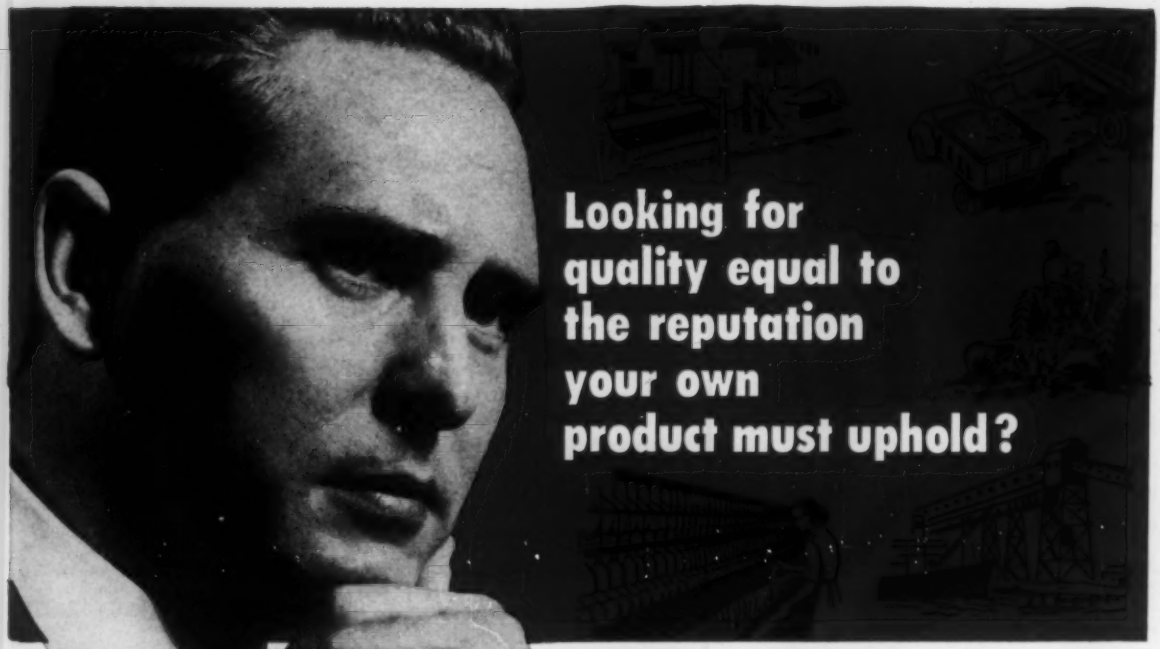
Circle 424 on page 19



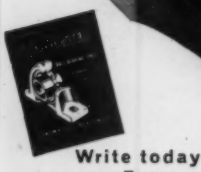
Looking for quality equal to the reputation your own product must uphold?

SEALMASTER'S

EXCLUSIVE COMBINATION OF FEATURES ASSURES NEW HIGH STANDARDS OF BEARING PERFORMANCE

Today, a designer who wants to get the most out of his product must look on components as part of his overall design. The fact that a bearing unit is just as essential to modern high performance and can cause failure of an otherwise perfectly engineered machine is reason enough for specific SEALMASTER recommendations. Each year as machinery gets faster, horsepower greater and manpower more costly, "downtime" becomes more critical.

No component you specify for the products you design or build will be of more dependable quality than SEALMASTER Ball Bearing Units. From design board to finished product SEALMASTER Bearings are the product of "Quality-minded" engineering and manufacturing processes backed by an exclusive combination of features. Find out today how important SEALMASTER Ball Bearing Units are to you!



Write today for your Free copy of SEALMASTER Catalog 454.

SEALMASTER
BALL BEARING UNITS

SEALMASTER BEARINGS, A DIVISION OF STEPHENS-ADAMSON MFG. CO., 18 RIDGEWAY AVENUE, AURORA, ILL.

Circle 425 on page 19

Circle 426 on page 19→

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 36

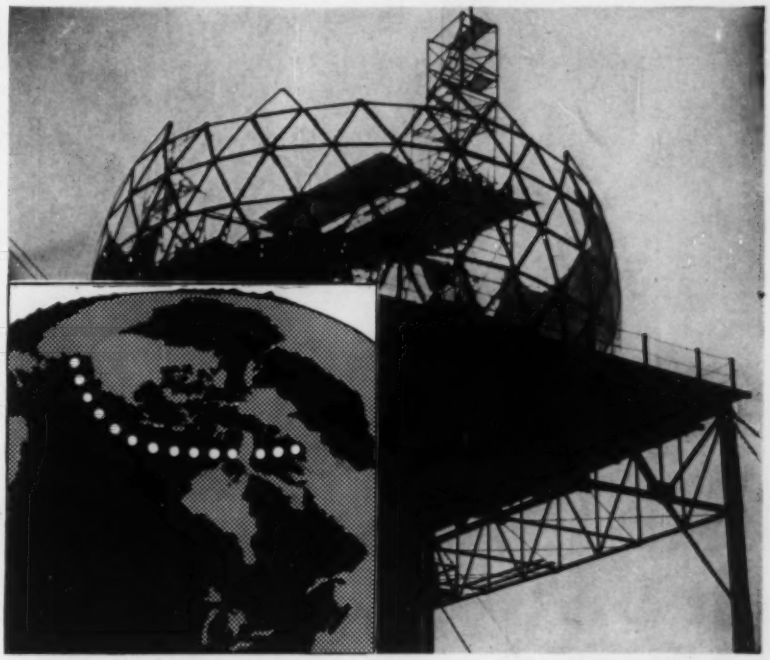
Silicone Fluid Aids Performance of Oil Well Drilling Instrument

Dow Corning Silicone Fluids have proven ideal for a growing number of damping, lubricating and fluid-filling applications where temperatures exceed the limits of organic oils. A case in point is the magnetic detector developed by McCullough Tool Company of Los Angeles which pinpoints underground "stuck points" in oil well pipe strings.

In order to protect the detector's electric micrometer magnets and balancing mechanism against well fluids, high temperatures and extreme hydrostatic pressure, the entire unit is filled under vacuum with Dow Corning 200 Fluid.

Typical underground conditions are revealed by the following data recorded in locating a "stuck point" over 3 miles below the surface of the earth: Mud weight—133 pounds per cu. ft. with a viscosity of 70; Hydrostatic head — over 15,000 psi; Temperatures—in the order of 460 F.

In the face of these conditions, Dow Corning 200 Fluid efficiently equalizes pressures to keep the detector from collapsing. It also acts as a heat-stable capacitor dielectric and transformer oil. Voltages inside the detector run as high as 300 volts at 120 cycles per second on 1/16-inch spacing. *No. 367*



"DEW LINE" RELIES ON DRY-TYPE TRANSFORMERS INSULATED WITH DOW CORNING SILICONES

New testimony to the extra reliability of Dow Corning silicone electrical insulation is provided by the transformers of the "DEW" defensive radar line now under construction north of the Arctic Circle.

In these remote yet vital installations, dependability and maintenance-free service are essential. That's why Western Electric Company, prime contractor for "DEW" electrical equipment and installation, specified silicone insulated dry-type transformers right down the Line. Most of the units, supplied by the Pittsburgh works of Allis-Chalmers, have been installed.

Designed for maximum dependability, minimum weight and a 302 F (150 C) temperature rise, the transformers range in size from 25 to 75 KVA. They are completely sealed and will withstand ambient temperatures as low as —60 F (—51 C) when idle.

While used primarily for station light and power, the DEW Line silicone insulated transformers will handle power for the radar signal in an emergency. *No. 368*

Pre-painting Sheet Metal Stock with Flexible Silicone Finishes Reduces Cost of Finished Parts

Blank, shape and trim finished parts from pre-painted sheet metal stock? May sound impossible, but Taylor Instrument Companies report it can be done, and economically . . . providing you use a silicone-based paint.

In manufacturing a new and permanently colorful oven thermometer, Taylor engineers found they could reduce production costs by applying a silicone coating to the metal stock *before* rather than after forming or shaping. After a short heat cure, the silicone finish is flexible enough to withstand the shearing, blanking, *(Cont. Pg. 2)*

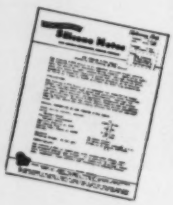
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



New Reference to Silicone Fluids describes the Dow Corning silicone fluids specified for most industrial and military applications. This convenient four page reference lists typical applications, and physical and electrical properties for each fluid — from flash point to volume resistivity. A useful and compact data source designed to help you select the silicone fluid most suitable for any specific application. *No. 371*

Low Pressure Laminating with Silicone Resins is a concise "how-to-do-it" manual that describes methods of making structural and electrical laminates for high temperature service. Also includes after-curing schedules. *No. 372*

"Rubber From Rock," a new color-sound movie, explains how Silastic, the Dow Corning silicone rubber, is manufactured from quartzite. Demonstrates why parts fabricated from Silastic retain rubber-like properties from —130 to over 500 F in a wide variety of military and industrial applications. Also covers uses for Silastic as a dielectric in electronic and electrical equipment. To arrange for a showing of "Rubber From Rock" in your plant, circle *No. 373*

All New—1957 Guide to Dow Corning Silicones is a twelve page, fact-filled reference describing the silicone products of interest to most industries. Containing latest data and information, the new 1957 Guide is designed expressly to help you enjoy the advantages, profits, and savings made possible through imaginative use of these versatile engineering materials. *No. 374*

"151 Uses for Silicones in Metalworking." A reprint from STEEL, condenses and lists known applications for silicones in Design, Production, Maintenance and Miscellaneous categories. Provides a quick but comprehensive review on how Dow Corning Silicones help solve problems in the metal-working industry. *No. 375*

Dow Corning Corporation, Dept. 6815, Midland, Michigan

Please send me: 367 368 369 370 371 372 373 374 375

NAME _____

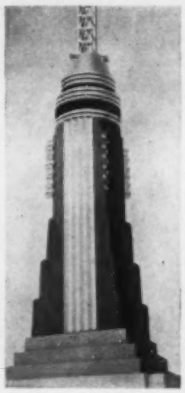
TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

Silicone-Glass Laminates Prove Stronger Than Ceramic Insulators



Although generally thought of only in connection with high temperature service, glass laminates bonded with Dow Corning silicone resins are superior in many ways to ordinary insulating materials at normal temperatures. Take low loss factor plus mechanical strength—

Since this combination of properties is usually attributed to ceramics, Andrew Corporation of Chicago used ceramic insulators when installing a special 4-corner television antenna for Station WATV atop the Empire State Building. But high winds and ice build-up on the antenna soon cracked the ceramic parts.

Andrew engineers then replaced all 240 ceramic insulators with silicone-glass laminate which is tougher than ceramic and not nearly as brittle. That was over two years ago and there hasn't been an insulator failure since! Engineers estimate the antenna will withstand a wind load of 50 psf with an inch thick layer of ice, or wind velocities up to 112 mph.

The superior mechanical strength of silicone-glass laminate is revealed in comparison tests conducted by Andrew engineers. Under cantilever loads, ceramic insulators cracked at 175 pounds and broke away at 235 pounds. Under similar conditions, the silicone-glass laminate was still holding well at 425 pounds. The tests were abandoned at this point because the quarter-inch stainless steel hold-down bolts were stretching out of shape.

Silicone-glass laminates also have excellent dielectric properties as shown by their qualifications for MIL-P-99713 in the following table. *No. 369*

Property	*Condition*	*Average Value*
Dielectric break-down parallel to laminations, step-by-step test, kv	A	33-100
	D-48/50	15-55
Dielectric strength perpendicular to laminations, step-by-step test, volts per mil	A	162-397 (1/8 inch thickness)
Dielectric constant at 1 megacycle, 1/8-inch thickness	E-96/50	3.8-3.59
	D-24/23	4.2-3.56
Dissipation factor at 1 megacycle, 1/8-inch thickness	E-96/50	0.0025-0.0014
	D-24/23	0.022 -0.0029
Insulation resistance, megohms	E-96/50	100,000-713,000
	D_1-96/50	0.44- 7,510
	C-96/35/90	2.38-10,000

FLEXIBLE SILICONE FINISHES *(continued)*

perforating and forming required to produce finished parts.

Taylor uses three colors of silicone paint —beige, green and red—formulated by the Stanley Chemical Company. The beige finish on the sandblasted steel thermometer case is cured for one hour at 450 F; the green finish on the alkaline-etched aluminum dial and the red finish on the bright-dipped brass pointer are each cured 30 minutes at 450 F.

Stanley Chemical recommends the silicone paints used by Taylor for use at temperatures up to 500 F. Other finishes formulated with Dow Corning silicone resins maintain excellent film integrity despite weathering, prolonged exposure to moisture, corrosive atmospheres and temperatures up to 1000 F. *No. 370*

SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION
MIDLAND MICHIGAN

first in silicones
DOW CORNING SILICONES

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For quickest service in solenoid valves, write for Skinner's Nationwide Stock List

The Skinner Nationwide Stock List covers the most universally applied Skinner Solenoid Valves for air and hydraulic service. All the valves listed are carried by every Skinner Stocking Distributor in the U. S. From his stock, your own local distributor can quickly meet your requirements. So for your own convenience, we urge you to write for this nationwide stock list of Skinner Solenoid Valves.

Skinner Stocking Distributors are located in all key industrial areas. If you have a solenoid valve problem, talk to the one nearest you. Tell him your requirements in regard to port sizes and locations, voltages, pressures, temperature conditions, capacities and mountings. Let him show you how easily he can select the valve you need.

For complete information on Skinner's line of exceptionally long-life 2-, 3- and 4-way valves, write us or contact a Skinner representative. Write Dept. 423

Skinner Solenoid Valves are distributed nationally

Circle 427 on page 19

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
103 EDGEWOOD AVENUE

CREST OF QUALITY

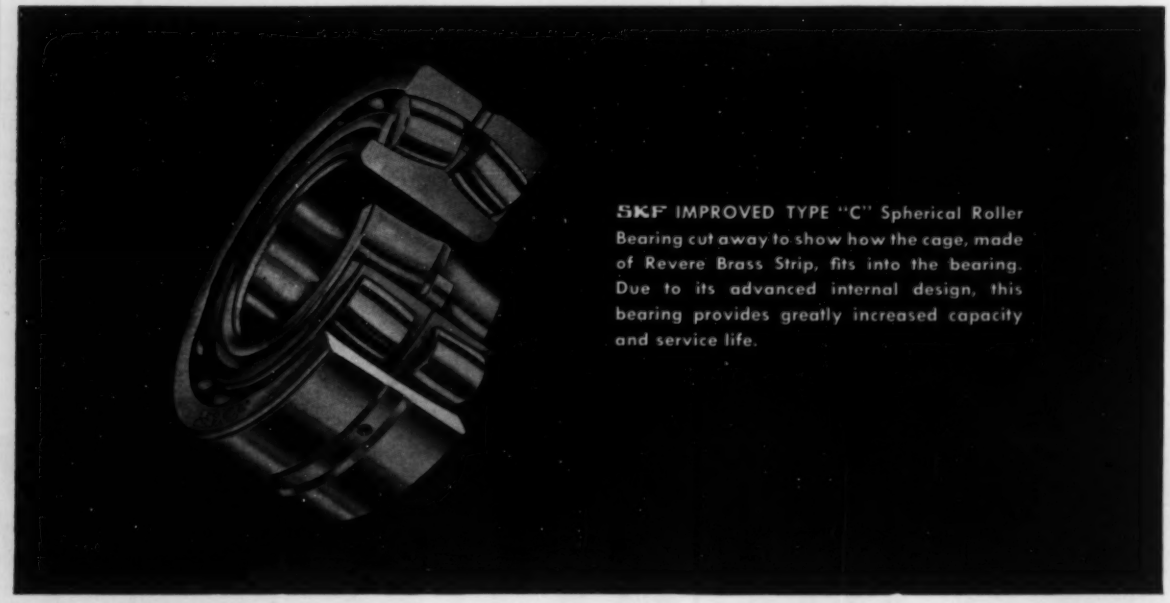
How SKF Saved in 7 Ways

and at the same time improved its roller bearing cages by using the right

Revere Brass Strip

SKF Industries, Inc., Philadelphia, Pa., like other progressive organizations, is constantly seeking new ways to improve its products and at the same time cut production costs.

With this in mind they recently reviewed the kind of brass which was being used in their spherical roller bearing cages from the standpoints of quality and fabrication. It was then that Revere's Technical Advisory Service studied the problem first-hand and made recommendations to the **SKF** production and engineering departments.



SKF IMPROVED TYPE "C" Spherical Roller Bearing cut away to show how the cage, made of Revere Brass Strip, fits into the bearing. Due to its advanced internal design, this bearing provides greatly increased capacity and service life.

HERE IS "window-type" cage of SKF Spherical Roller Bearing, made in two pieces, one for each row of rollers. Cage is made from rugged Revere Brass Strip at the Shippensburg, Pa., plant of SKF Industries, Inc.

The result was the adoption of specification changes in brass strip as recommended by Revere which gave SKF these 7 money, time and tool-saving advantages:

1. One bore pressing operation has been eliminated. Machining is more easily accomplished. Less machining is required.
2. Tool life has been increased with some speeds increased up to 100% and feeds up to 30%.
3. Rework due to burrs has been greatly reduced. One step less is required in the deburring operation while savings through reduced cycle time for remaining deburring operations are up to 40%.
4. Chips are small now . . . there is no "angel hair" to clutter work area.
5. Life of punch used in notching roller bearing cage has been doubled. Now a run may be completed without making tool adjustments due to sharpening tools.
6. Machining speeds and feeds have been substantially increased over those in machining the former alloy.
7. Die setters report that considerable work has been eliminated in setting up the tools used.

And, all of these money-saving things were accomplished without sacrificing quality—in fact the quality of these roller bearing cages was *improved!*

This is still another eye-opening example of Revere supplying the metal that will do the best job and with the greatest economy . . . be it brass, copper or aluminum or any one of their alloys.

Why not call in Revere's Technical Advisory Service to review your operation? It may mean money saved with an improved product to boot.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

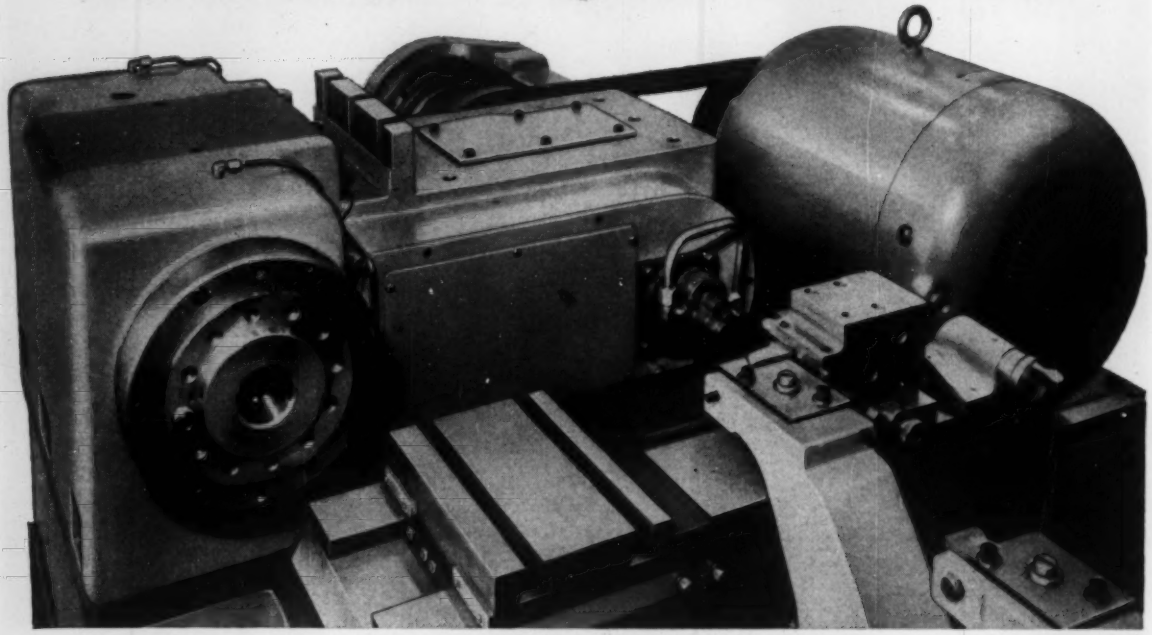
230 Park Avenue, New York 17, N.Y.

Mills: Baltimore, Md.; Brooklyn, N.Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

COPPER • BRASS • 18 01 • REVERE • ALUMINUM

WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY

WAGNER MOTORS mean less down-time for production machinery



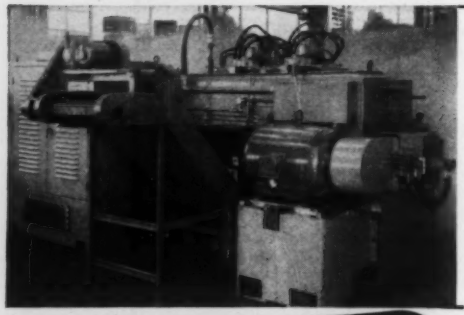
This Wagner Type EP Motor is mounted on the base of the Reedmatic Production Lathe.

Wagner totally-enclosed fan-cooled motors will give your machine tools the drives they need to give continuous service.

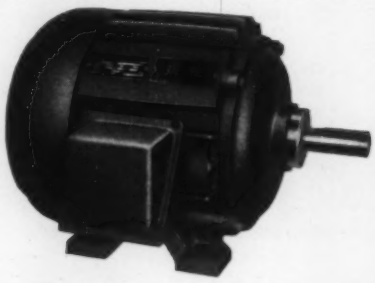
THEY ASSURE LESS DOWN TIME. Wagner totally-enclosed fan-cooled motors are *fully* protected against damage from steel filings, chips, dust, dirt, fumes and moisture. This built-in protection assures freedom from excessive down time caused by motor failure.

THEY REDUCE MAINTENANCE COSTS. Wagner totally-enclosed motors require no maintenance other than periodic lubrication. These motors are designed to run cooler and longer between maintenance periods, but when greasing is necessary, readily accessible lubrication openings permit addition of grease or a complete relubrication.

A Wagner field engineer will be glad to help you design non-stop performance into your production machinery by recommending the motors that best fit your specific needs. Just call the nearest of our 32 branch offices.



This Reed-Prentice tracer controlled automatic production lathe, which turns automobile axles in 30 seconds, is equipped with Wagner Type EP totally-enclosed fan-cooled Motors. These motors are fully described in Bulletin MU-203. Write for your file copy today.



M37-6

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

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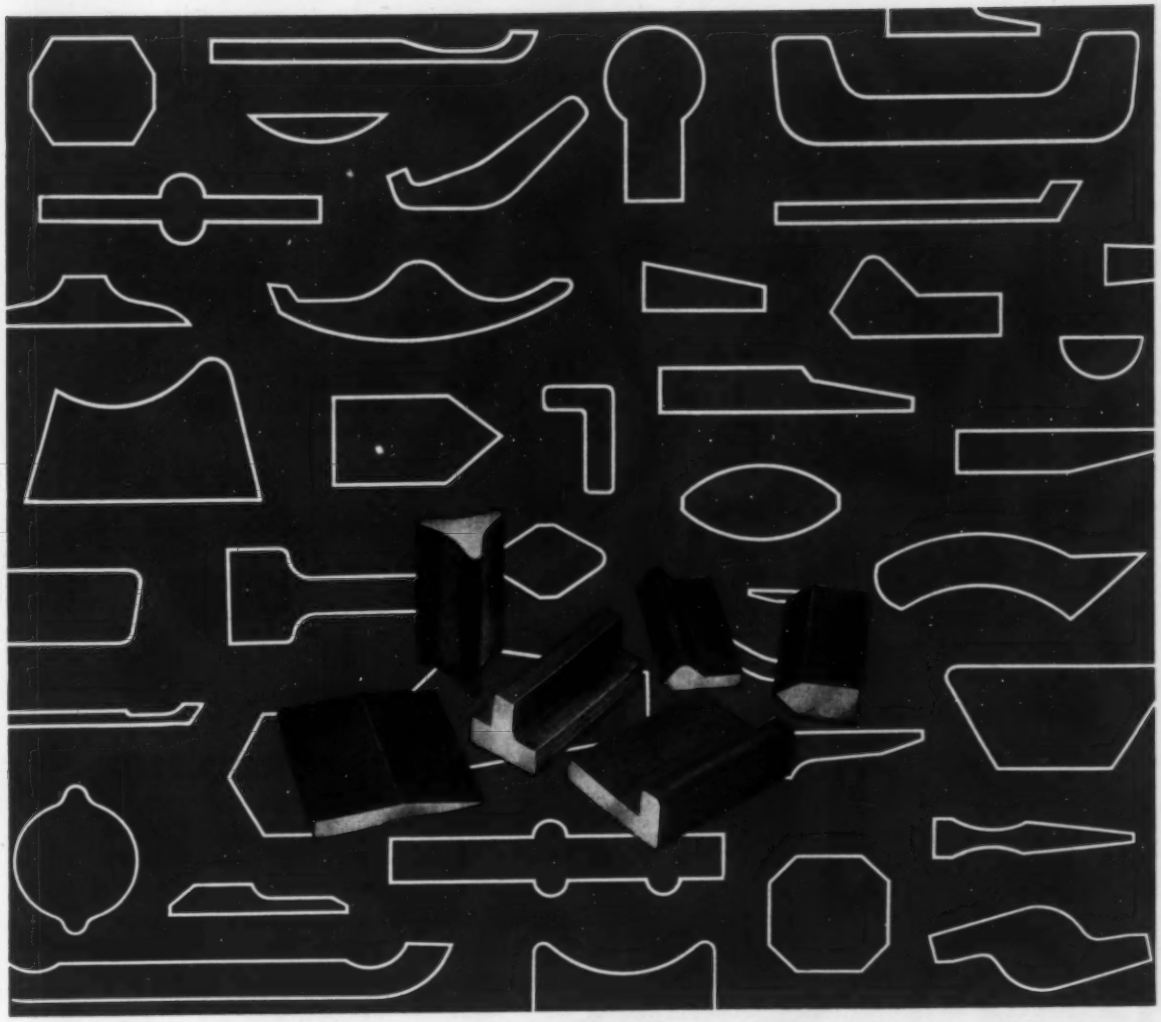


Crucible special shapes

for better alloy steel parts at lower cost . . .

If you're machining intricate sections from solid bars—or using expensive forgings—stop! Choose instead, a *Crucible special shape* that approximates the finished part. *Crucible special shapes* eliminate rough-machining operations . . . reduce scrap losses.

There's practically no limit to the *special shapes* available at Crucible, in a wide variety of alloy steels. Rolls for over 400 special shapes are available—other shapes can be rolled to your specifications. Your local Crucible representative can give you the whole story of how *special shapes* can cut costs—save time. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

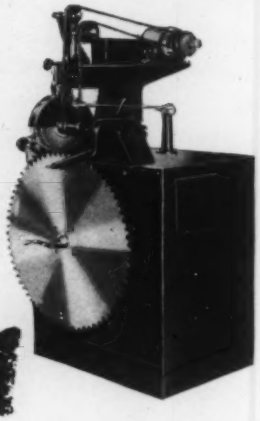
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Circle 430 on page 19

These applications demonstrate the self-aligning ability of the ***HEIM Unibal***

This linkage controls the shuttle motion of the label loom made by Fletcher Works of Philadelphia. This application visually demonstrates the ease with which misalignment can be corrected.

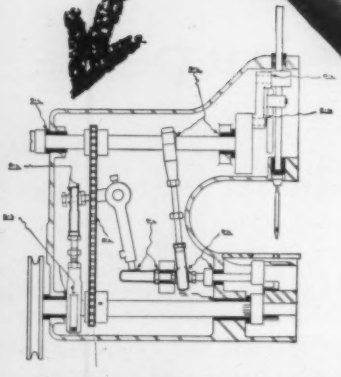


On this Armstrong Sharpener, which handles saws up to 120" in diameter, the push-pull rod with a Heim Unibal Rod End at each end, provides the universal motion for changing direction of the grinding wheel smoothly, quietly, and with precision for extreme sensitivity in grinding fine teeth.

Where shaft misalignment must be corrected . . .

The HEIM *Unibal* ROD END

is a single ball rotating in a bronze bearing race. It offers freedom of movement such as cannot be obtained with any similar mechanism. As a self-aligning bearing, it compensates for designed or unavoidable shaft or stud misalignment. Because of the large area of contact between the ball and the bronze bearing inserts, much greater load ratings are possible for substantially smaller envelope dimensions.



The Minneapolis Sewing Machine Co. uses Heim Unibal Rod Ends to take care of a 25° operating misalignment in the linkages in their model H-150 portable sewing machine.

Please feel free to write our engineering department about your linkage problems, and be sure you have sufficient copies of the Heim catalog for all designing, operating, and purchasing departments.

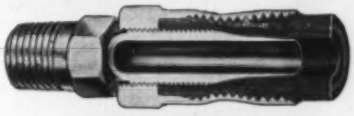
THE HEIM COMPANY / Fairfield, Connecticut

WEATHERHEAD

First in components for HYDRAULIC SYSTEMS

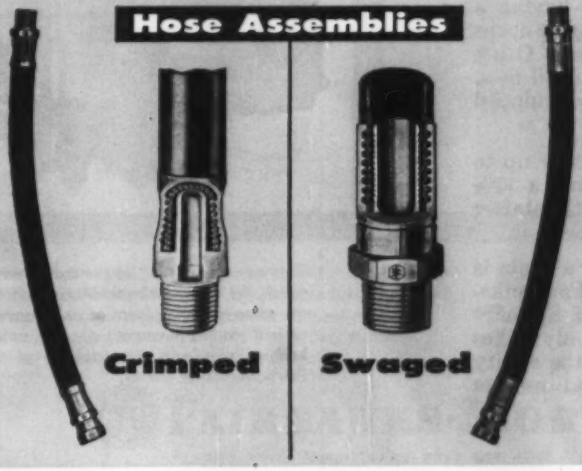
Look at anything . . . anywhere in the world . . . in hydraulics, diesel power or machine tool applications . . . equipment for instrumentation, oil drilling, mining, road building, petro-chemicals or even atomic power . . . chances are the vital air and fluid lifelines are secured with WEATHERHEAD.

Reusable Hose Ends



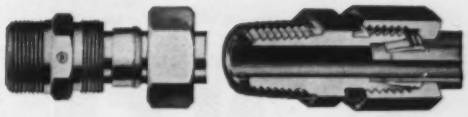
Bulk Hose

Hose Assemblies



Crimped | Swaged

ERMETO



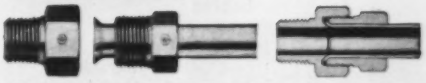
SAE 37° FLARE

3-PIECE

2-PIECE

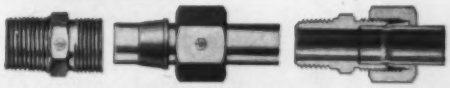
SAE 45° FLARE

INVERTED FLARE



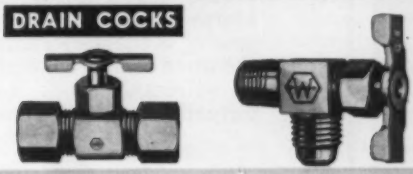
COMPRESSION

SELFALIGN



PIPE

DRAIN COCKS



WEATHERHEAD

FIRST IN HYDRAULIC CONNECTIONS

THE WEATHERHEAD CO., FORT WAYNE DIVISION

Dept. AB-3, 128 West Washington Blvd., Fort Wayne, Indiana

In Canada: The Weatherhead Co., Ltd., St. Thomas, Ontario

WEATHERHEAD

The only single-source hydraulic hose and fitting line.

Circle 432 on page 19

NEW FROM FAIRBANKS-MORSE

SURE-FIRE PUSHBUTTON STARTS FOR SMALL GASOLINE ENGINES

Muscles are going out of style for starting small gasoline engines. New pushbutton-actuated electric starters being introduced by Fairbanks-Morse do the job much better.

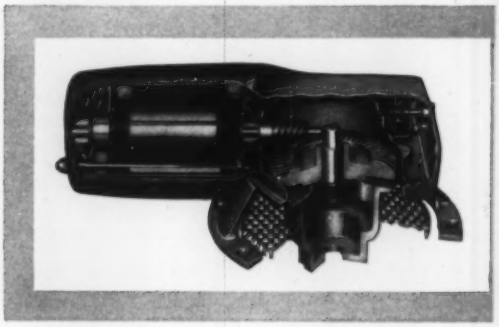
You don't have to redesign your gasoline engine to use the starter. A Fairbanks-Morse starter operated by either a 12-volt battery or 110-volt a-c power fits right on the same mounting as a conventional rewind starter.

Battery-operated Fairbanks-Morse starters give you added freedom of operation — particularly with mobile units that often require starting at a distance from an a-c power source. Also — having a battery mounted right on the engine opens the field for advanced design ideas. Other power accessories, impractical until now, can be added readily to a battery-equipped engine.

A charger that brings the battery up to full charge by being plugged into a 110-volt a-c outlet overnight keeps the starter ready to go at all times.

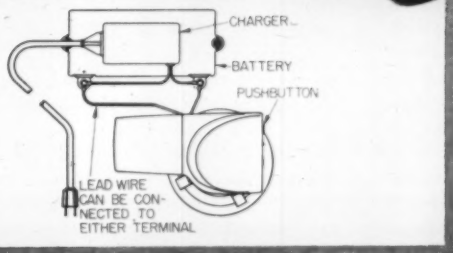
Direct drive without requiring a chain is another major feature of the Fairbanks-Morse electric starter. Use of Spiroid® gearing in the starter drive not only makes the drive compact but gives it the ability to withstand shock loads and assures virtually trouble-free operation.

- **STREAMLINED** for Eye Appeal
- **EASY TO MOUNT** without Engine Redesign. Replaces conventional starter
- **DIRECT DRIVE** — No Chain Required
- **COMPACT** with Reliability Proved by Extensive Field Tests

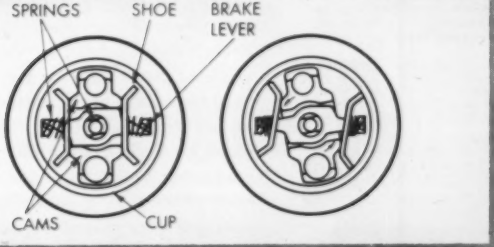


Cutaway of starter demonstrates ease with which the new Fairbanks-Morse unit fits into the same mounting location as a conventional rewind starter. Compact gearing contributes both to style and dependability of the new Fairbanks-Morse starter.

Style, compactness, and rugged performance are features of the new Fairbanks-Morse pushbutton starter. Gear-driven start instead of the old-fashioned chain assures quick, positive performance.



Starter, battery, and charger are combined in a neat package by Fairbanks-Morse. Considerable flexibility is possible in arranging components to meet needs of any gasoline-powered engine. The battery makes use of other power accessories practical.

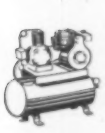
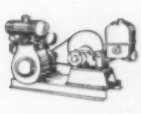


Rotor assembly of rugged Fairbanks-Morse unit. Rotation forces cam-actuated special alloy shoes outward until they grip the inner wall of the cup as shown in sketch. Being spring-loaded, shoes disengage instantly when start button is released.

FAIRBANKS-MORSE

A name worth remembering when you want the BEST

MAGNETOS • REWIND STARTERS • WATER SYSTEMS • GENERATING SETS
PUMPS • MOTORS • SCALES • DIESEL LOCOMOTIVES AND ENGINES

SEND FOR BULLETIN

Fairbanks, Morse & Co., Magneto Div.
Beloit, Wisconsin

( ) Send Bulletin FM273 describing electric starter.

( ) Have representative call.

Name_____

Company_____

Address_____

City_____ State_____

Circle 433 on page 19

Copyflex Machines and Sensitized Materials

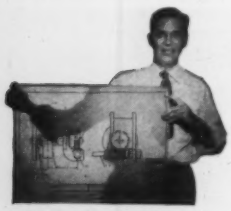
ADD MANPOWER TO YOUR DRAFTING ROOM

Modern Reproduction Machines, Materials, and Techniques Cut

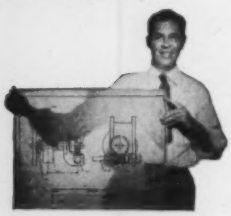
The boom in production means more pressure than ever for engineering prints and drawings. Now, more than ever, is the time to (1) replace that old, inadequate reproduction unit with a modern, efficient Copyflex machine and (2) capitalize on the many drafting shortcuts made possible by Copyflex reproduction machines and sensitized materials.

Six New, Advanced Machines: In just the past 18 months Bruning has introduced six new, greatly improved models—five of which are shown at right. They bring you not only faster reproduction but a host of design improvements that will boost your drafting room output sharply. One of these six new machines will surely meet your exact requirements.

Slash Re-Drafting Time: Your Copyflex machine is more than a means of making conventional opaque prints of finished drawings—it can also help you in your actual drafting operations. In many cases involving the re-working of existing drawings, for instance, it can save you up to 90% in tracing time through the use of translucent prints ("intermediates") made on film, cloth, or low-cost paper. Consider how much of your drafting is devoted to design changes, changes in standards, and similar alterations and you'll see why adding Copyflex to your production team will *add manpower to your drafting room.*



This design change took hours to make because it was done entirely at the drawing board.



The same design change was completed in less than an hour with the aid of a Copyflex intermediate.

These Materials Speed Reproduction *and* Drafting

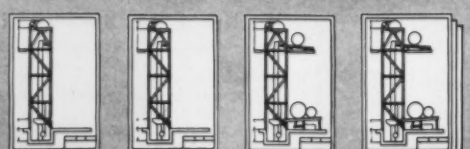
Copyflex Translucent Sensitized Paper: Prints made on this 100% rag, resin-transparentized medium provide: (1) a positive, reproducible image of all or any selected part of an original; (2) a workable drawing surface for making additions or alterations; and (3) excellent translucency for making fast, sharp reproductions. In the making of design changes, prints made on this paper eliminate the need for tracing those sections of the design which do not require alteration. Unwanted portions can either be masked out in the printing operation or eradicated on the translucent print . . . then new lines added. The paper prints accept pencil and ink, and drawn lines are erasable. Subsequent alterations are achieved just as easily and quickly by use of the same reproduction-drafting technique.

Copyflex Sensitized Matte Film: Usable for same purposes as Copyflex Translucent Sensitized Paper, but is highly transparent and much more durable. Reproduces faster than originals made on tracing paper.

Copyflex Sensitized Clear Film: Offers complete transparency and extremely fast reproduction speed. Not suitable for drawing, but ideal for making composite prints, overlays, and projection prints. Various developers can be applied to it to produce different color effects.

Copyflex Sensitized Tracing Cloth: A top quality moisture repellent cloth with excellent pencil and ink workability. The ideal material to use when circumstances require a translucent print with exceptional durability and strength.

HOW COPYFLEX SPEEDS DESIGN CHANGES



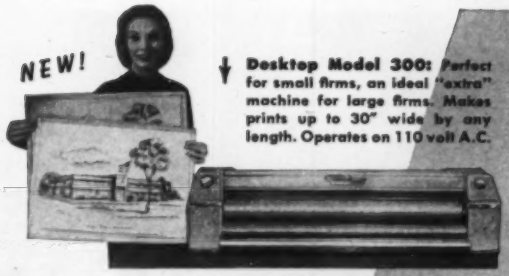
Original Drawing | Translucent Print of Original | Print with Alterations Drawn In | Prints Made from Altered Intermediate

Problem: To make a design change without marking or altering the original drawing or tracing.

Old Method: (1) Trace unchanged parts of the original by hand; (2) draw in the design changes or alterations.

Copyflex Method: (1) Reproduce unchanged parts of the original in a matter of seconds on Copyflex translucent paper, cloth, or film—blocking out or later eradicating any unwanted portions of the original design; (2) draw in the design changes or alterations.

Result: Substantial savings in time, money, and drafting room manpower.



NEW!

Desktop Model 300: Perfect for small firms, an ideal "extra" machine for large firms. Makes prints up to 30" wide by any length. Operates on 110 volt A.C.

Drafting Time, Boost Productivity!

NEW!

Model 500: A heavy-volume machine offering top mechanical speed of 40 f.p.m., 46" printing width, automatic separation and stacking, front or rear delivery, and many other advanced features.

Model 250: Takes less than a sq. yd. of floor space. Has top mechanical speed of 25 f.p.m., 18½" printing width, automatic separation and stacking. Operates on 220 volt A.C.

Model 200: A 110 volt A.C. version of the Model 250.

NEW!

NEW!

Model 35: Provides up to 30 f.p.m. mechanical speed and a full 46" print-width for heavy volume reproduction at a thrifty, low cost.

Model 20: Not a new model, but a dependable performer well worth your consideration. Makes prints up to 46" wide. Operates on 110 volt A.C.

Model 30: A faster, 220-volt version of the Model 20.

Desktop Model 110: A new and improved small machine with 11" printing width. Makes 8½"x11" prints for less than 1¢ each for materials. The helper your big machine needs!

NEW!

SEND FOR MORE INFORMATION TODAY!

BRUNING Copyflex

Best Process! Best Machines!
Best Selection of Materials!

Offices in 37 Cities of the U.S. and Canada

CHARLES BRUNING COMPANY, INC., 4700 Montrose Ave., Chicago 41, Ill.
In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

Charles Bruning Company, Inc., Dept 33-K
4700 Montrose Ave., Chicago 41, Illinois

Please send me information on the Copyflex process and the following machine(s):_____
and sensitized materials:_____

Name_____ **Title**_____

Company_____

Address_____

City_____ **County**_____ **State**_____

MicroRold® STAINLESS SHEET

Type 430 Bright Finish

up to 48" WIDE

BRIGHTER THAN EVER!—MicroRold stainless steel Type 430 in the NEW Bright Finish is now immediately available in sheets up to 48" wide offering new usefulness and economy in stainless fabrication. Produced with the same micro-accuracy of gauge for which MicroRold 36" is well known, Type 430 Bright up to 48" wide gives greater latitude in applications for quality stainless steel.

MicroRold 430 is also available in the regular commercial finishes and MicroRold stainless in other grades are now produced up to 48" wide. Complete details sent on request.

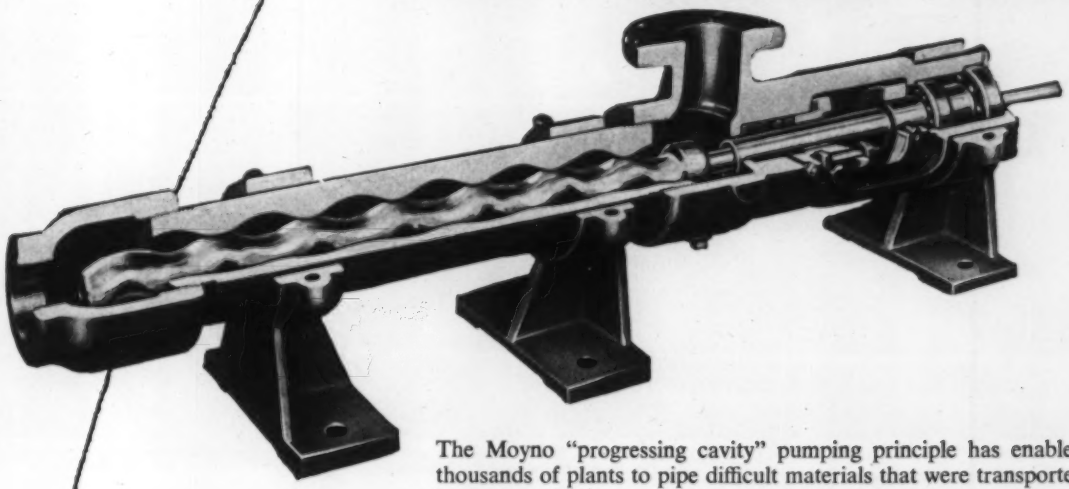
Washington Steel
Corporation
3-E WOODLAND AVENUE WASHINGTON, PA

Circle 435 on page 19

from abrasive slurries to delicate foods . . .

MOYNO® PUMPS

CUT HANDLING COSTS



The Moyno "progressing cavity" pumping principle has enabled thousands of plants to pipe difficult materials that were transported by hand and other expensive means. Moyno is the only pump that can handle many abrasives, pastes, slurries, chemicals, foods, suspended solids, etc., without foaming, aerating, crushing or excessive pump wear.

As shown above, Moyno Pumps have a screw-like rotor that revolves in a double threaded stator creating progressing cavities which smoothly move material through the pump. They will pump anything that will move through a pipe . . . even plaster and non-pourable pastes!

Moyno Pumps are available in capacities up to 500 gpm and pressures up to 1000 psi.

Examine your processing methods. No doubt there are several places where Moyno Pumps can drastically cut costs. Ask us, we'll give you a frank answer. Send us an outline of your problem today! Write for Bulletin 30-MD

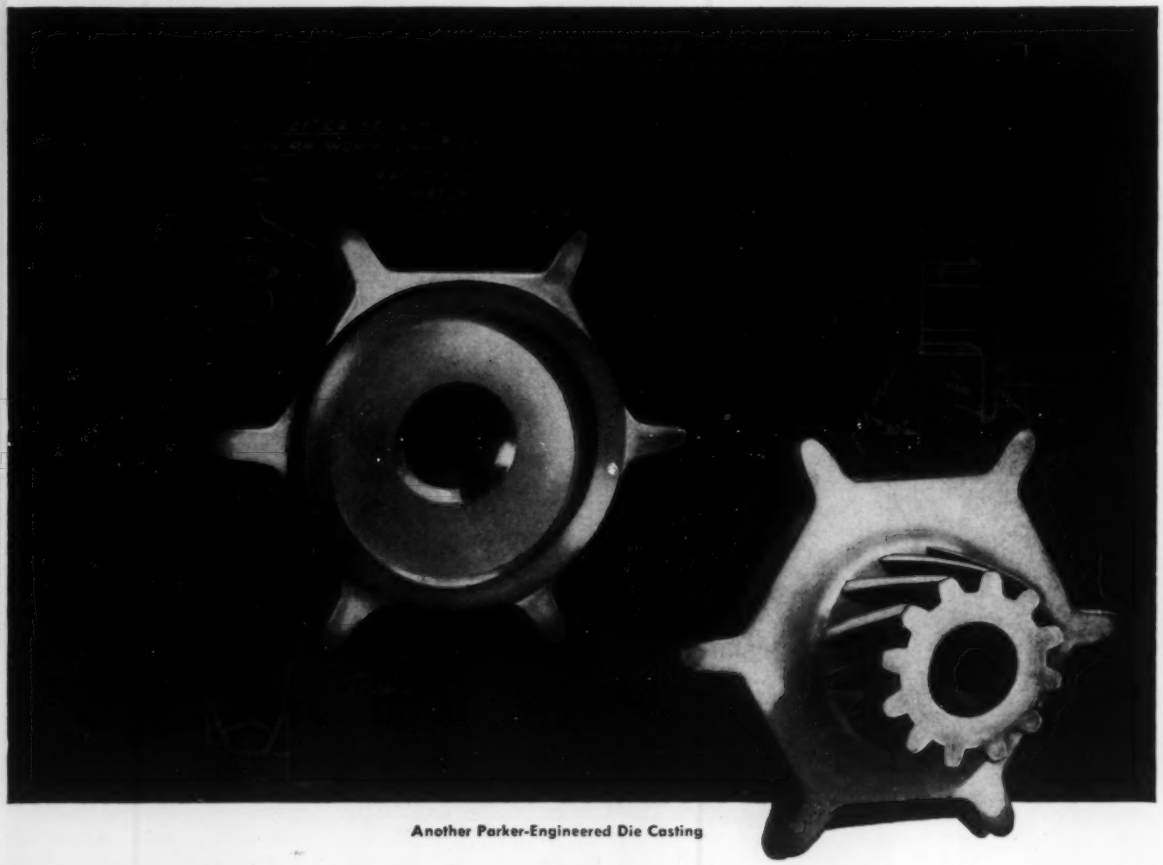
R&M

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

Motors | Fans | Hoists | Moyno® Pumps | Propellair® (Industrial) Fans

Circle 436 on page 19



Another Parker-Engineered Die Casting

MACHINED PRECISION at DIE-CASTING COST!

PARKER SALES ENGINEERS

CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street

CINCINNATI, Ohio
William H. Broxterman • 2174 Buck Street

DETROIT 35, Mich.
Hodgson-Geisler Co. • 18917 James Couzens

GIRARD, Penna.
Daniel F. Marsh • 35 Chestnut Street

KIRKWOOD 22, Mo.
Edward F. Higgins, Jr. • 102 West Adams Street

WILTON, Conn.
Girard L. Palmer • Belden Hill Road

SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.

BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street

Produced complete in one operation . . . to extremely close tolerances . . . this helical gear part is yet another example of the way Parker-engineered die castings can save you money by eliminating costly tooling-up and machining operations on component parts. Combine this inherent cost advantage with exceptionally smooth as-cast finish, high density and good tensiles and you can see why Parker Die Castings—in zinc or aluminum—open up wide new possibilities to the design engineer.

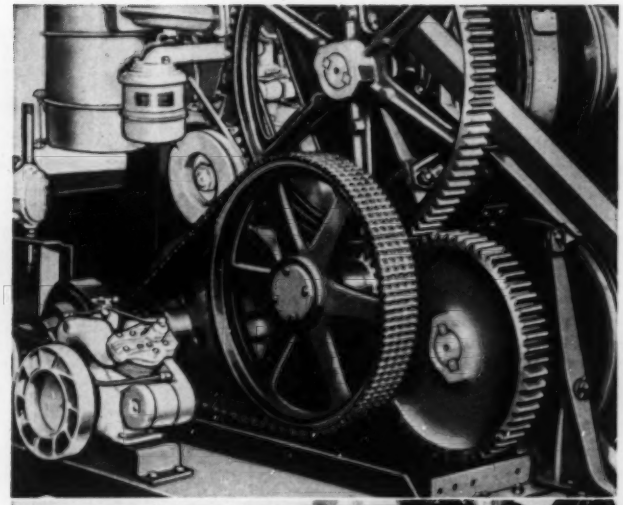
Parker has been a leader in die-casting for 50 years—an old hand with new ideas. Take advantage of this skill. Just call the nearest Parker sales engineer or write the factory direct.

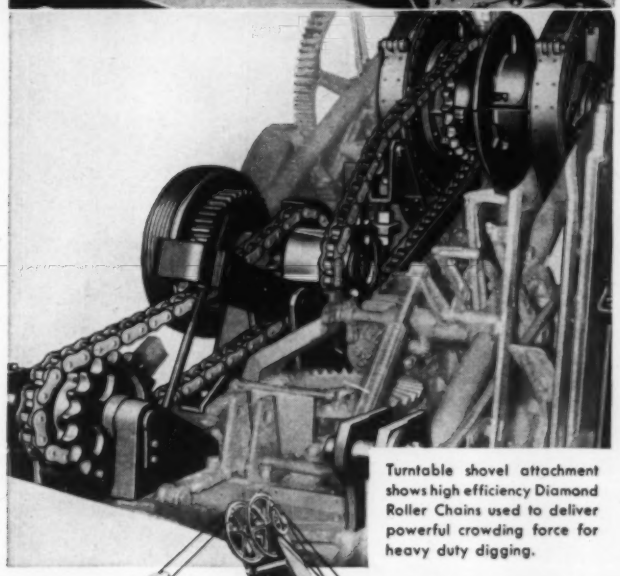
Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

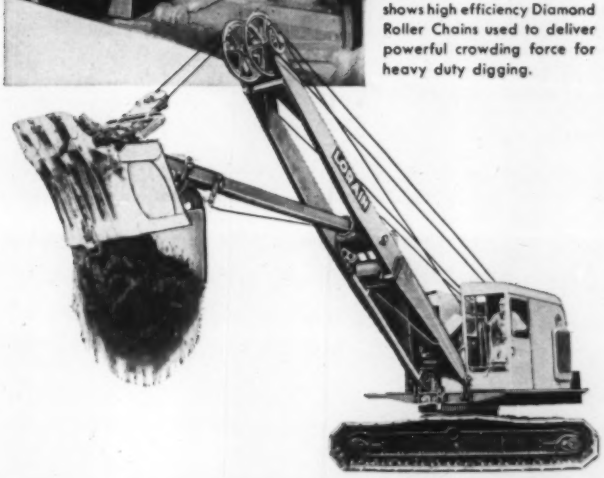
high pressure ALUMINUM and ZINC die castings POWDERED METAL PARTS

Circle 437 on page 19





Turntable shovel attachment shows high efficiency Diamond Roller Chains used to deliver powerful crowding force for heavy duty digging.



98-99% EFFICIENCY OF DIAMOND ROLLER CHAINS

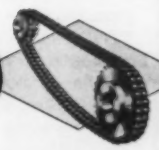
Turns More Engine Horsepower into Useful Work!

The Lorain Series 50 turntable is packed with extra power and strength. The reason is *direct-to-the-point* application of engine power. These excerpts from the Lorain catalog tell why . . . .

". . . There is no long train of power-consuming, efficiency-reducing gears . . . no intervening jack shaft . . . instead a multiple roller chain transmits power directly to the center drive pinion. This pinion, in turn, directly powers the independently clutch-controlled Hoist and Swing Travel Shafts."

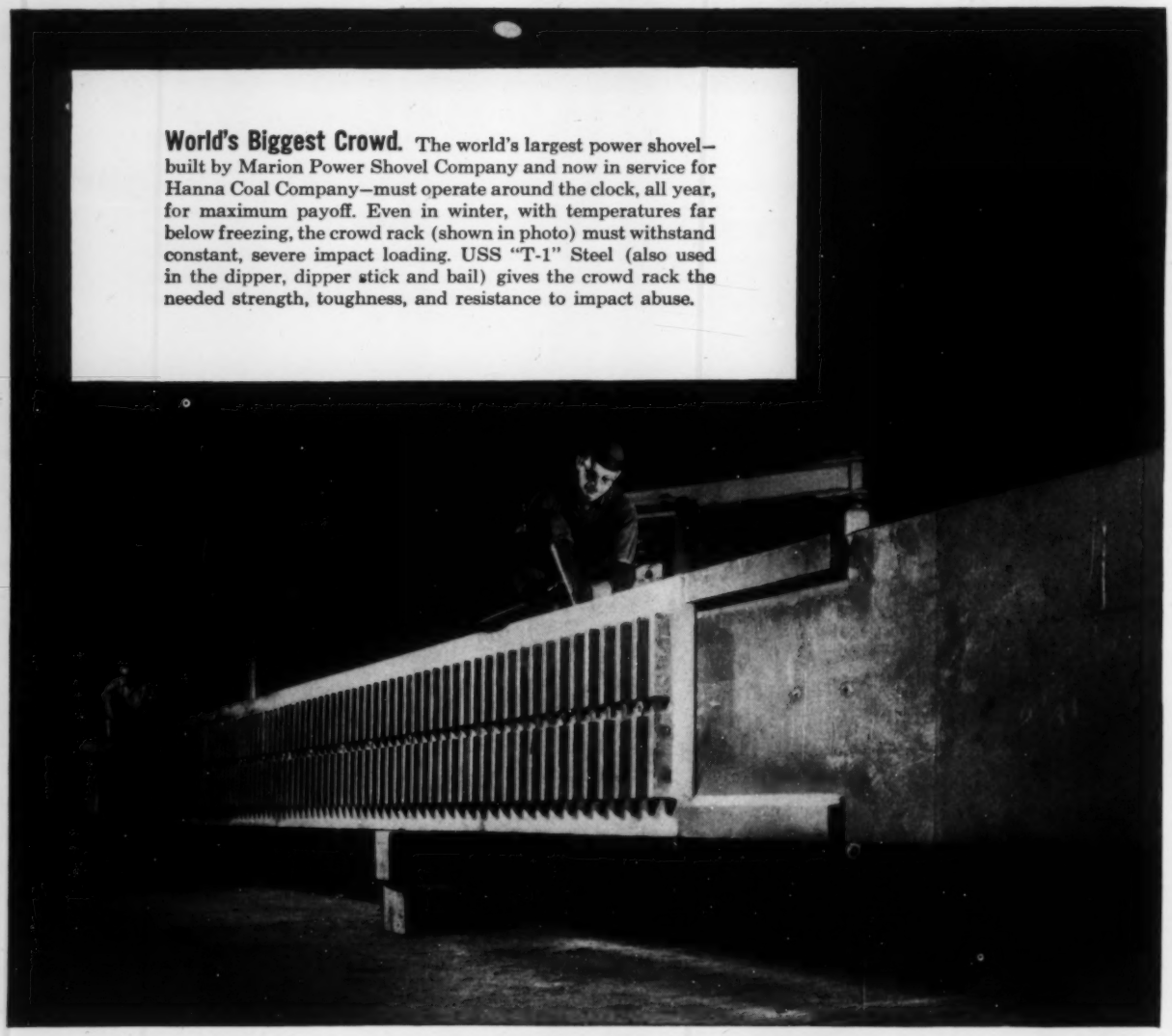
For dependable, long-life power take-off drives and for crowding, retracting and propelling, Diamond Roller Chains are first choice with leading manufacturers and contractors alike. Diamond quality means maximum performance at lowest cost.

DIAMOND CHAIN COMPANY, Inc.
Where High Quality is Traditional
Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana
Offices and Distributors in All Principal Cities

DIAMOND  **ROLLER CHAINS**

Circle 438 on page 19

HOW USS "T-1" STEEL IMPROVES THESE

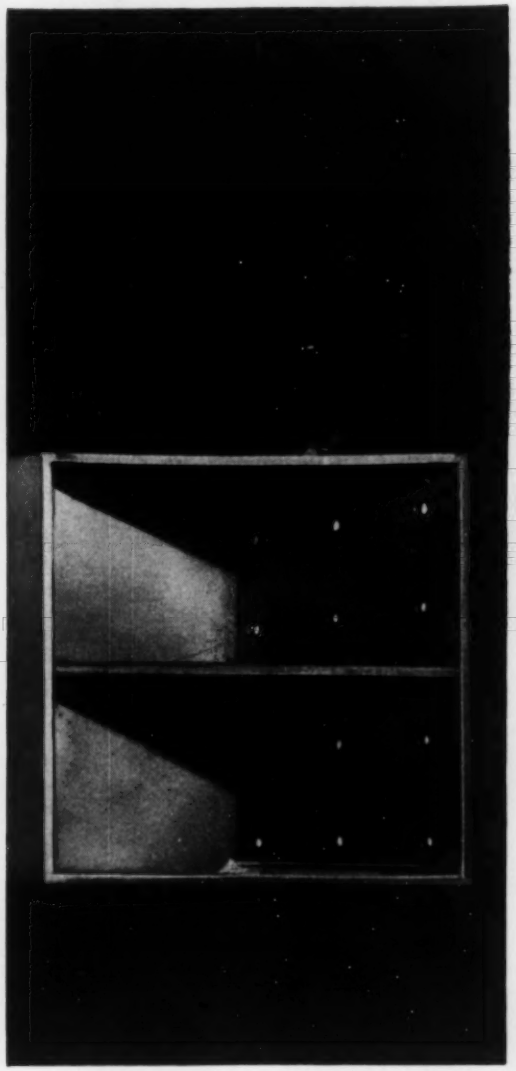


World's Biggest Crowd. The world's largest power shovel—built by Marion Power Shovel Company and now in service for Hanna Coal Company—must operate around the clock, all year, for maximum payoff. Even in winter, with temperatures far below freezing, the crowd rack (shown in photo) must withstand constant, severe impact loading. USS "T-1" Steel (also used in the dipper, dipper stick and bail) gives the crowd rack the needed strength, toughness, and resistance to impact abuse.

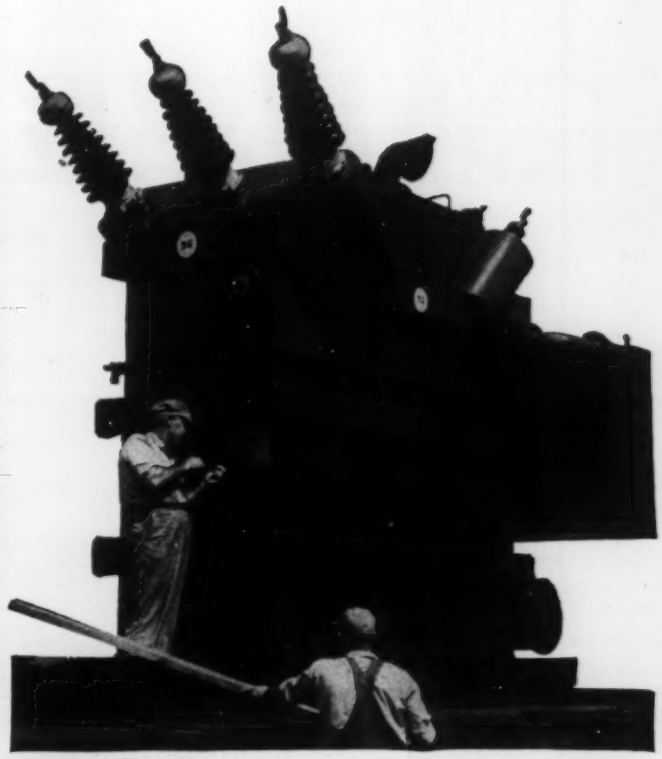
Unlined Bin. Here are the "makings" of an *unlined* coal storage bin being made by Fairmount Machinery Company, Fairmount, West Virginia. The very high strength of USS "T-1" Steel reduced weight and made the bin simpler to build because it cut down the number of stiffening members needed. USS "T-1" Steel will be welded in the field to cut fabricating costs. Good resistance to abrasion and corrosion of USS "T-1" Steel eliminated need for special lining inside the bin.

USS

PRODUCTS:



SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.



Smallest Portable. This is the smallest 69 kv power transformer ever built by Maloney Electric Company, St. Louis, Missouri . . . occupies a space only 7' 11" x 14' 8", overall. Over a ton of weight was saved in the tank, alone, by using USS "T-1" Steel. The very high yield strength of this steel reduced the necessary thickness of the steel from ⅜" to ¼". The "T-1" Steel shell was fabricated by Nooter Corporation, St. Louis. The transformer—rated at 9,000 kva—was designed for Oklahoma Gas & Electric Corporation.

HOW MUCH DO THEY WEIGH?

It's a contest. With prizes. The occasion: The Design Engineering Show in May. The reason: To get you in to see the "T-1" Steel exhibit. Here's all you do: Visit the U. S. Steel Booth and guess the weight of the "T" and the "1" which will be on display there. The pieces were flame-cut from USS "T-1" Steel. Visit our exhibit and see just how versatile this steel is. You may win a prize!

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

"USS" and "T1" are registered Trade Marks

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

FENWAL'S THERMOSTATS NOW CIGARETTE SIZE

Some Units Smaller Still
Take Little More Room Than Sugar Lump

ASHLAND, MASS. — If you want to control temperatures in tight spots, you should see Fenwal. Fenwal has cut the size of thermostats way down.

You can fit one of their Midget THERMOSWITCH units anywhere a cigarette will fit. And, if you're working with even less space, one of their Miniature THERMOSWITCH units is what you're looking for. The Miniatures are little bigger than a lump of sugar, and some are even smaller.

The Midgets and Miniatures use the same unique principle used in Fenwal's bigger THERMOSWITCH controls. They use it with the same high degree of success.

The principle of all Differential Expansion THERMOSWITCH units, large or small, is this: a single metal shell expands or contracts with temperature changes, making or breaking totally enclosed electrical contacts.

The smallness of the Midget and Miniature units does not deprive them of any of the performance characteristics that have made larger THERMOSWITCH units famous. They have THERMOSWITCH ruggedness, THERMOSWITCH accuracy, and reasonable THERMOSWITCH prices.

Temperature range of the Midget series: −50°F to 500°F. Range of the still smaller Miniature series: −20°F to 275°F.

Midgets and Miniatures, all in stainless steel, come in a variety of mountings. Hermetic sealing is also available.

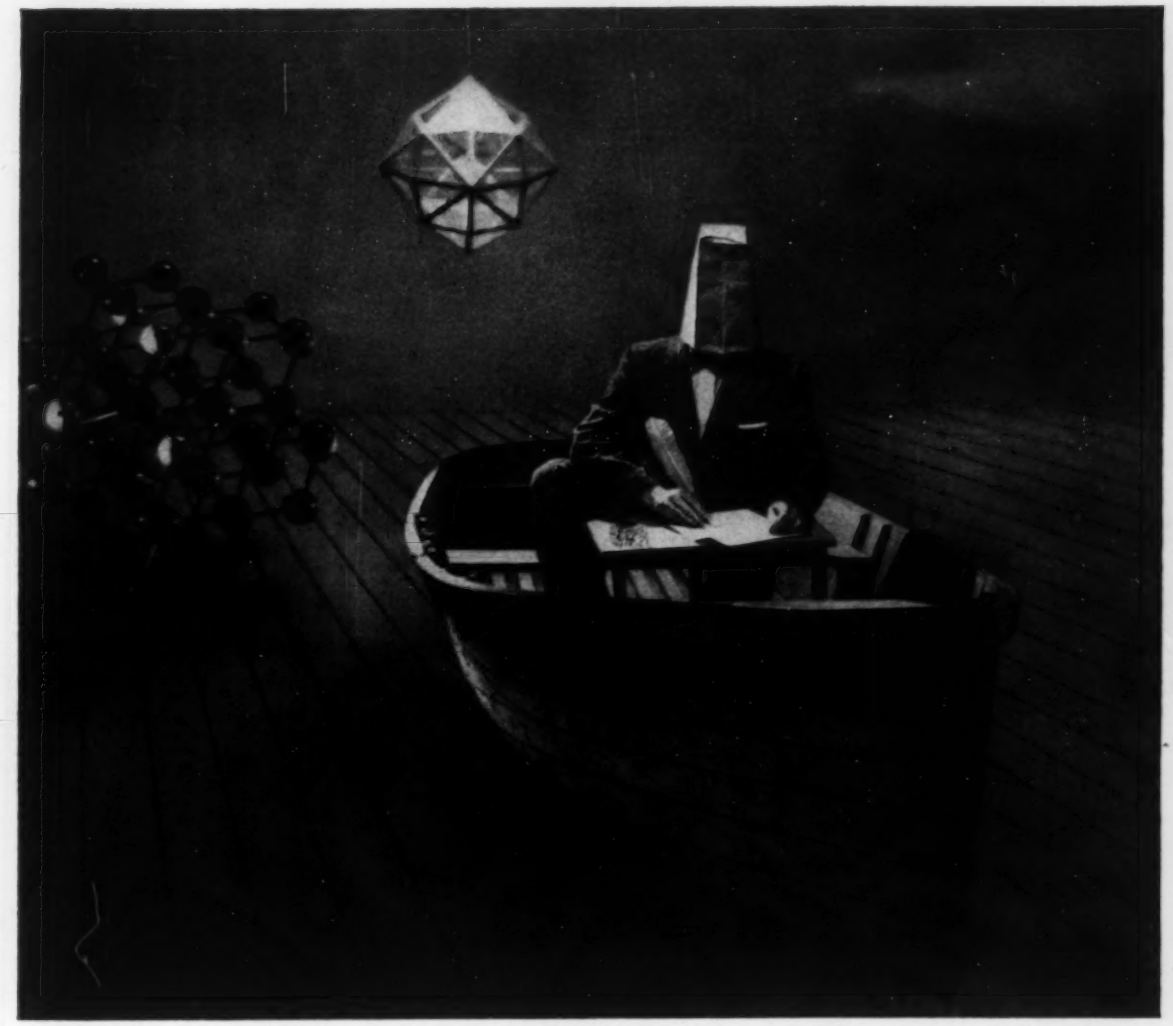
These Fenwal THERMOSWITCH units are precision-engineered to give optimum temperature control with minimum-sized devices. They remain accurate under the most severe operating conditions.

You should have details on this advance in temperature control at your fingertips. Write for information to **Fenwal Incorporated, 193 Pleasant Street, Ashland, Massachusetts.**

THERMOSTATS FOR TIGHT SPOTS — A Fenwal Midget THERMOSWITCH® unit and a Fenwal Miniature THERMOSWITCH unit — two good answers to the question, "How can you install an accurate, reliable thermostat where there's almost no room?" Actual sizes of these particular models — ¼" x 2 25/32" for the Midget; 1" x ½" for the Miniature.

Fenwal

CONTROLS TEMPERATURE
...PRECISELY



A Man Nobody Wants

This man's motto is "Don't rock the boat!" Now that he has reached his present high post in the Company, his life is dedicated to proving that once you get a good thing, you don't have to change. In fact, if things get too new, you can always search the past for something really safe to use.

He, naturally, has no interest in the new things coming out of Rogers.

Rogers is not looking for him, either. Rogers serves engineers – those men who sail the seven seas in search of an eighth. And they, in turn, find Rogers an interesting port of call – a cove of research and development brains eager to meet the challenge of their ideas with new materials.

Our business is to create – if we don't already have them – the materials that engineers are seeking to convert today's dreams into actual products. Please write for samples of recent developments.

ROGERS
CORPORATION
ROGERS, CONNECTICUT

DUROIDS—for Gaskets, Filters, Electronic Devices, Thermal Insulation, etc. ELECTRICAL INSULATION—for Motors, Transformers, Generators, etc.
SHOE MATERIALS—for Counters, Midsoles, Liners, etc. PLASTICS—Special Purpose Molding Compounds and Laminates RUBBER—for Floats, Grommets, Gaskets, Bearing Seals, etc.
FABRICATING—Including Converting, Combining, Coating, Embossing, and Molding DEVELOPMENT—Research and Engineering of Unique Materials, Parts and Products

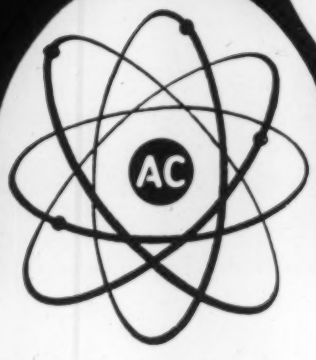
MECHANICAL ENGINEERS

DESIGN

DEVELOPMENT

PRODUCTION

Ever wanted to be a member of a real championship team?? As a member of the Product Development Engineering Department your "team play" will include:



DESIGN You create basic design concepts based on practical means of accomplishment. Your concepts are translated by layout draftsmen to a more communicable form under your guidance. In other words, HOW, WHAT, WHY, WHERE systemized.

DEVELOPMENT You evaluate, refine and improve; using the finest PRODUCT IMPROVEMENT TOOLS. These "TOOLS" include the best TEST and RESEARCH facilities available and you have the added advantage of working alongside the top men in this field.

PRODUCTION You supervise the evolution of a production model based upon engineering prototypes resulting from the Design and Development. Produceability and a high degree of reliability will be your responsibility. Your job will include the maintainability and function of Electro-Mechanical Devices, Precision Gear Trains and Packaged Electronics in the fields of Inertial Guidance, Avionics and Jet Engine Fuel Controls.

Job assignments are accomplished by men operating as a team. Our program is expanding and Challenging Opportunities await qualified men for important positions on our Engineering teams. Why not you??
As a part of our Major, Permanent, Company Expansion Program, new plant facilities are being added in suburban Milwaukee.

RECENT ME GRADUATE INQUIRIES ALSO INVITED

Milwaukee offers ideal family living in a progressive, neighborly community combining cultural and shopping advantages with small town hospitality. You and your family will love Milwaukee.
To arrange personal, confidential interview in your locality send résumé today to

Mr. Cecil E. Sundeen
Supervisor of Technical Employment

the ELECTRONICS DIVISION

GENERAL MOTORS CORP.

FLINT 2, MICHIGAN • MILWAUKEE 2, WISCONSIN

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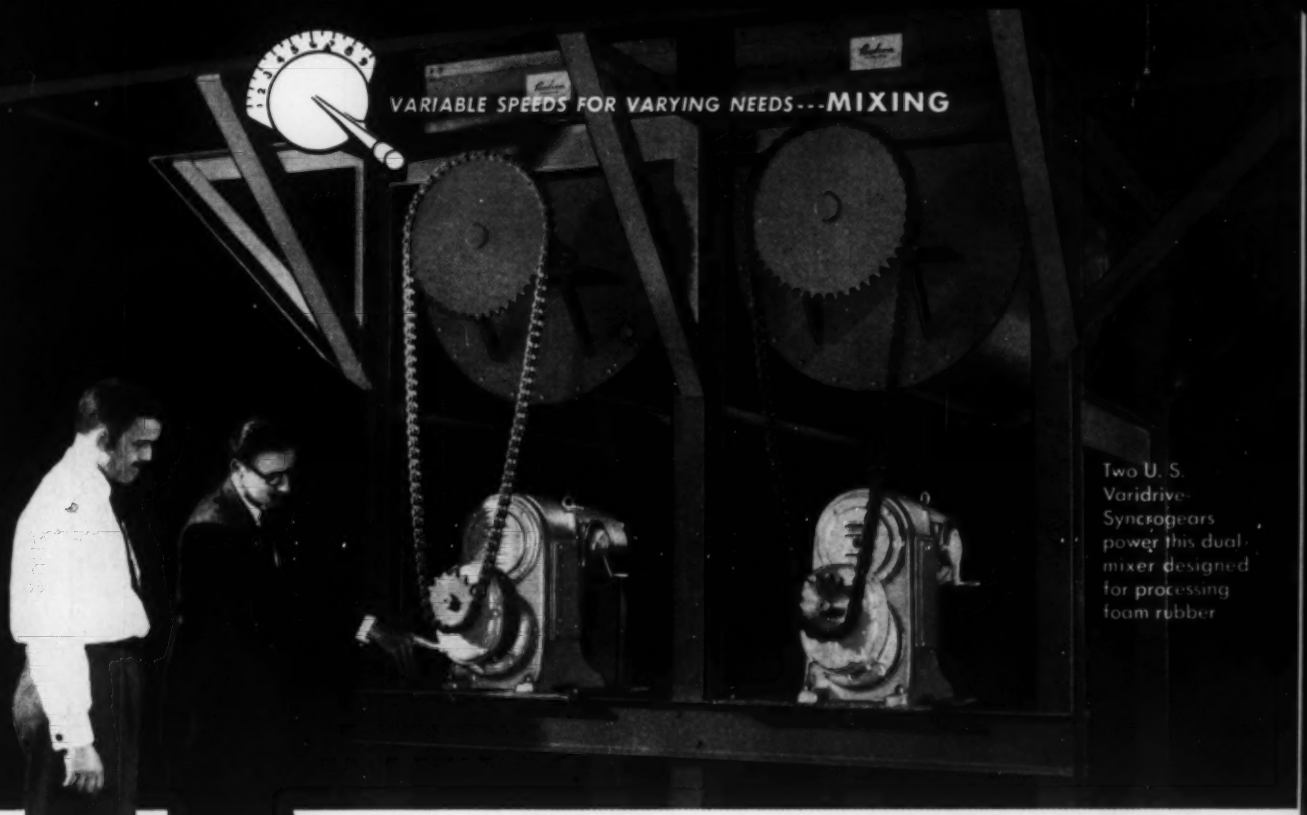
Circle 443 on page 19→



Two U. S. Varidrive-Syncrogears power this dual mixer designed for processing foam rubber

Question: **"WHY DOES VARIABLE SPEED IMPROVE MIXING?"**

Answer: **"BECAUSE THERE'S ONE RIGHT SPEED FOR EVERY MIXING CONDITION—"** *for example:*

VISCOUS MATERIALS Where dry ingredients are mixed or reacted with vehicles or binders, the materials may go through a plastic state in their reaction; therefore variable speed increases or decreases rpm speed to accommodate the process requirements.

TEMPERATURE VARIATIONS When liquids or semi-solids undergoing mixing lose heat, the speed of the mixer may require reduction progressively or in steps. A Varidrive will give you the precise speeds needed at different levels of temperature.

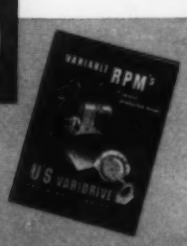
BATCH BLENDING Different consistencies of batch materials may require slow speed to start, but when they become integrated, higher speed may be applied to reduce time. The same mixer can be used for processing materials of widely varying consistencies by powering it with a Varidrive. Thus you save space and extra equipment.

EXPERIMENTAL PROCESSES You may want to mix new compounds or blends to determine how slow or fast you should make up the batch. Only by variable speed can you get the sensitive rpm needed for experimenting. Varidrive is the answer.

INCREASED VERSATILITY A mixer can be used for many operations with variable speed, whereas a single-speed will restrict its use. A Varidrive gives a mixer its full potential of performance so that you may be able to avoid purchase of extra mixers.

U.S. Electrical MOTORS

U.S. ELECTRICAL MOTORS Inc. • Box 2058, Los Angeles 54, Calif. or Milford, Conn.



Send today for Full Color 16-page Comprehensive Booklet fully describing the

U.S. VARIDRIVE

¼ to 60 hp—2 to 10,000 RPM

New Republic

REPUBLIC NYLOK NUTS offer advantages similar to those of Nylok bolts. They can be assembled from either end with hand or power tools, and lock tight wherever wrenching stops. Holding power is not affected by vibration. "Plastic memory" of nylon pellet gives Nylok nuts excellent adjustment and re-usability characteristics.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Self-Locking Nylok Bolts

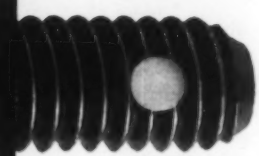
Provide Single-Unit Answer to Vibration, Liquid-Sealing and Adjustment Problems

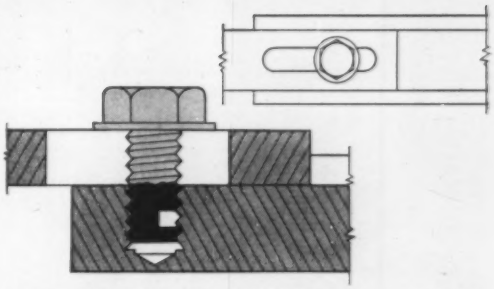
If your bolted assembly must be vibration-proof, liquid-tight or adjustable—Republic Self-Locking Nylok® Bolts are your best fastener selection. You simply align parts to be fastened and turn Nylok bolt into threaded hole. A positive lock is provided, whether or not the unit is seated.

In addition, use of Nylok bolts eliminates lost motion of assembling extra locking devices or expensive wiring. They can be hand wrenched or power driven to minimize fastening time—a tremendous asset in high-volume production runs.

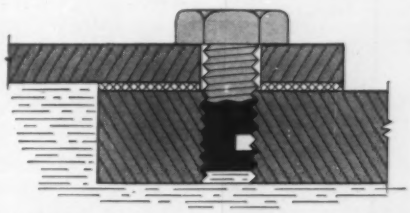
Locking is accomplished by means of a permanent nylon insert in the body of the bolt. This pellet wedges opposite mating threads together to form a vibration-proof lock. There is no damage to threads or seating surfaces, and the insert's resiliency allows fasteners to be adjusted and re-used repeatedly. Further, when properly seated, the nylon insert effectively blocks fluid flow around the helix of the threads. Even relatively soft materials can be locked to a threaded member using Nylok bolts.

When you specify Republic Nylok Bolts you secure the double protection of Nylok locking plus Republic quality, built into each fastener from raw ore to finished product. To find out how you can take full advantage of this ideal combination, contact your Republic representative. Or mail the coupon for further information.

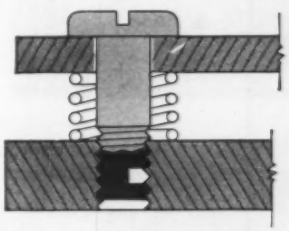




ADJUSTMENT problems like this movable plate are readily solved using Nylok bolts. The nylon pellet allows bolt to be backed off and wrenched tight time after time, without damage to threads, seating surfaces or holding power. Unaffected by age, immune to fungus, pellet won't dry out or shrink.



LIQUID SEALING properties of the Nylok bolt are demonstrated here. Nylon pellet, seeking to regain its original shape, effectively interrupts space between non-loadbearing surfaces of mating threads. Escape of fluid along helical thread path is blocked. Nylon's resistance to moisture and ordinary solvents assures permanence of seal.



VIBRATION has no effect on the locking characteristics of Nylok bolts, even when not wrenched tight as shown here. Secure grip is provided by nylon pellet permanently imbedded in fastener body. Continual pressure of resilient nylon forces tight metal-to-metal lock between mating threads opposite the pellet.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-2704
3130 East 45th Street,
Cleveland 27, Ohio

Please send me further information on Republic Nylok Bolts and Nuts.

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

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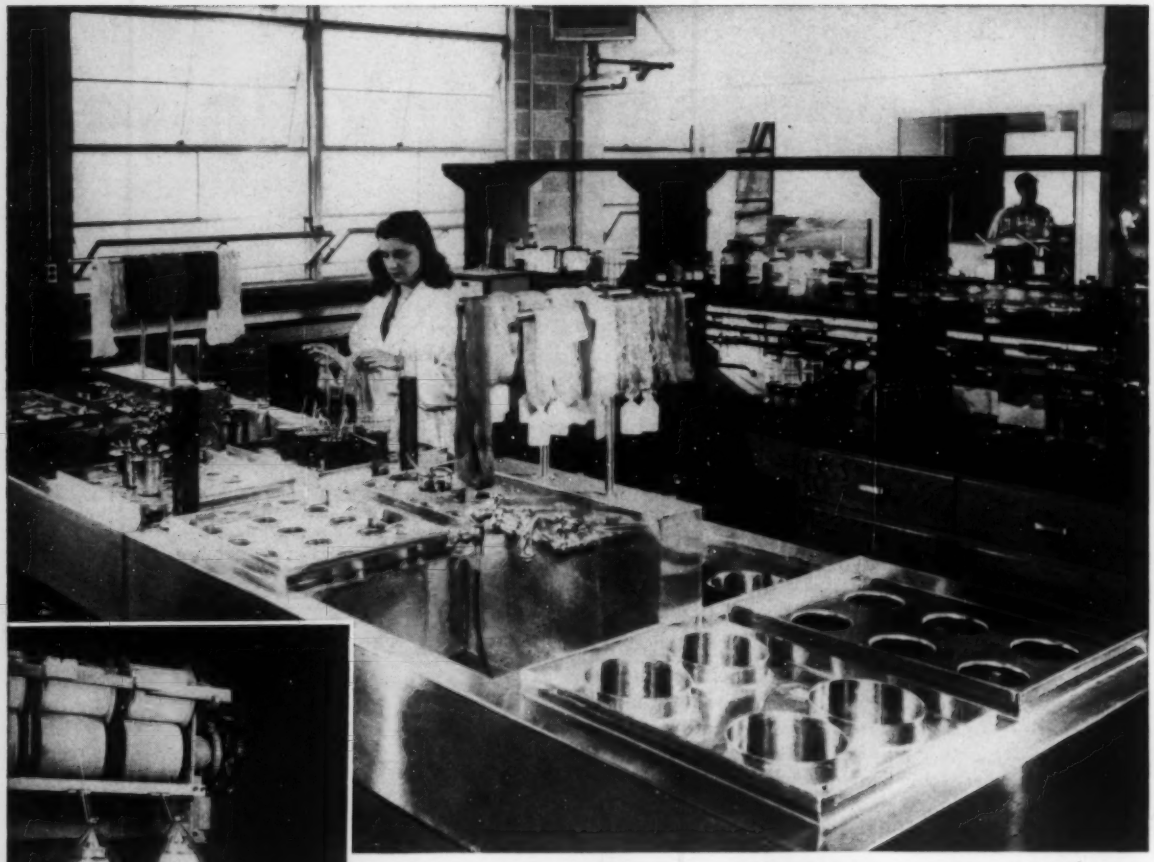
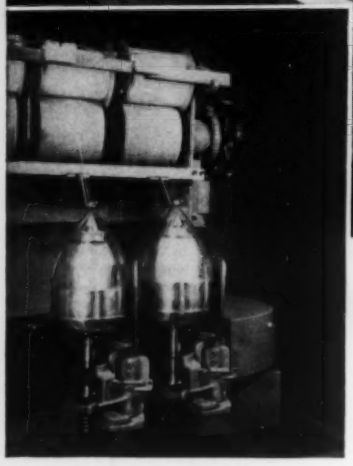




Wherever you want to protect something
. . . that's a place for A-L Stainless Steel

In a textile plant, like the applications pictured above, Allegheny Ludlum Stainless Steel protects against off-colors in the dyeing and finishing department because it cleans up easily and quickly from batch to batch, leaving no traces of the previous dyes. In yarn twisters and other equipment in the weaving department, A-L Stainless provides the hard, smooth surface and high abrasion-resistance that protects against snagging and binding.

Food, beverage, dairy, drug and chemical plants use A-L Stainless Steel to protect the purity of their products; hospitals, hotels and restaurants use it to protect appearance and sanitary standards; cars, trains and planes use it to protect strength and safety. And they all gain a host of bonus benefits from stainless steel, too: such as far less cleaning and maintenance expense, far longer life in service, and far greater economy in the long run.

No other metal can match stainless steel in these qualities. In addition, A-L Stainless is easy to fabricate and we produce it in every form or shape that you may require.

● Let us help you to profit by it. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

Write for your copy of
"STAINLESS STEEL IN PRODUCT DESIGN"

40 pages of useful engineering and fabricating data, including practical examples showing where, when and how stainless steel improves design, adds benefits, helps sales.

ADDRESS DEPT. MD-87

For Stainless Steel in ALL Forms—call

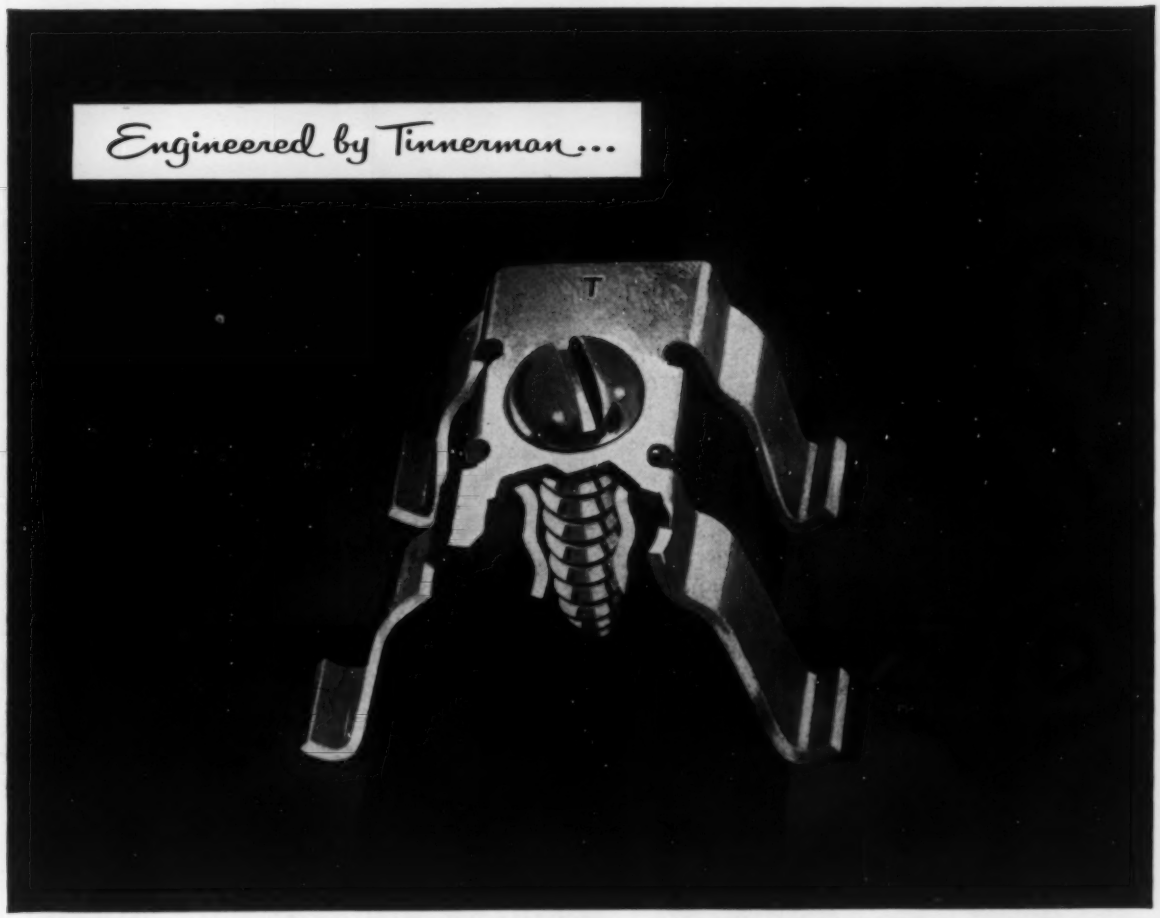
Allegheny Ludlum

Warehouse stocks carried by all Ryerson Steel plants

AL STAINLESS STEEL

WSW 6092

Circle 445 on page 19



6-fingered **SPEED CLIP**®
holds glass panels tight, saves 46%!

This special SPEED CLIP fastens glass panels to aluminum extrusions with a grip that prevents slippage. Heat stays in, rain stays out of greenhouses and similar glass structures. Working closely with engineers of the Metropolitan Greenhouse Mfg. Corp., Brooklyn, Tinnerman developed this unique fastener that saves almost one-half the cost of former less effective assembly methods!

Installation is fast and simple. Two overlapping glass panels are positioned against the extrusion. A screw driven into the spring-steel SPEED CLIP spreads the two center fingers outward to grip the inner walls of the extrusion. No secondary fastening devices required—SPEED CLIPS hold tight, yet are easily removed to permit replacement of glass.

This is another example of a fastener engineered by Tinnerman to satisfy special, complicated fastening problems. A Fastening Analysis of your products may produce a similar cost-cutting solution. See your Tinnerman representative soon.

TINNERMAN PRODUCTS, INC.
BOX 6688 • DEPT. 12 • CLEVELAND 1, OHIO

TINNERMAN

Speed Nuts®

FASTEST THING IN FASTENINGS®

Canada: Dominion Fasteners, Limited, Hamilton, Ontario. Great Britain: Simmonds Aerocessories, Limited, Treforest, Wales. France: Simmonds, S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). Germany: Hans Sickinger GmbH "MECANO", Lampe-I-Lippe.

flattening a wrinkle or blasting an invader . . .

LINEAR SILICONE "O" RINGS
MAINTAIN A PERFECT OIL SEAL
under high heat and pressure . . .

The workaday steam iron and the guided operational missile have a common need: Both require seals which withstand *extremes in temperature and pressure.*

In these and many more applications beyond the ordinary thermal range, LINEAR SILICONE "O" RINGS provide the answer. The product of Linear pioneer research, these specially compounded "O" Rings retain flexibility at temperatures as low as —130° F. Yet they also maintain dimensional stability . . . resist compression set at temperatures as high as 500° F.!

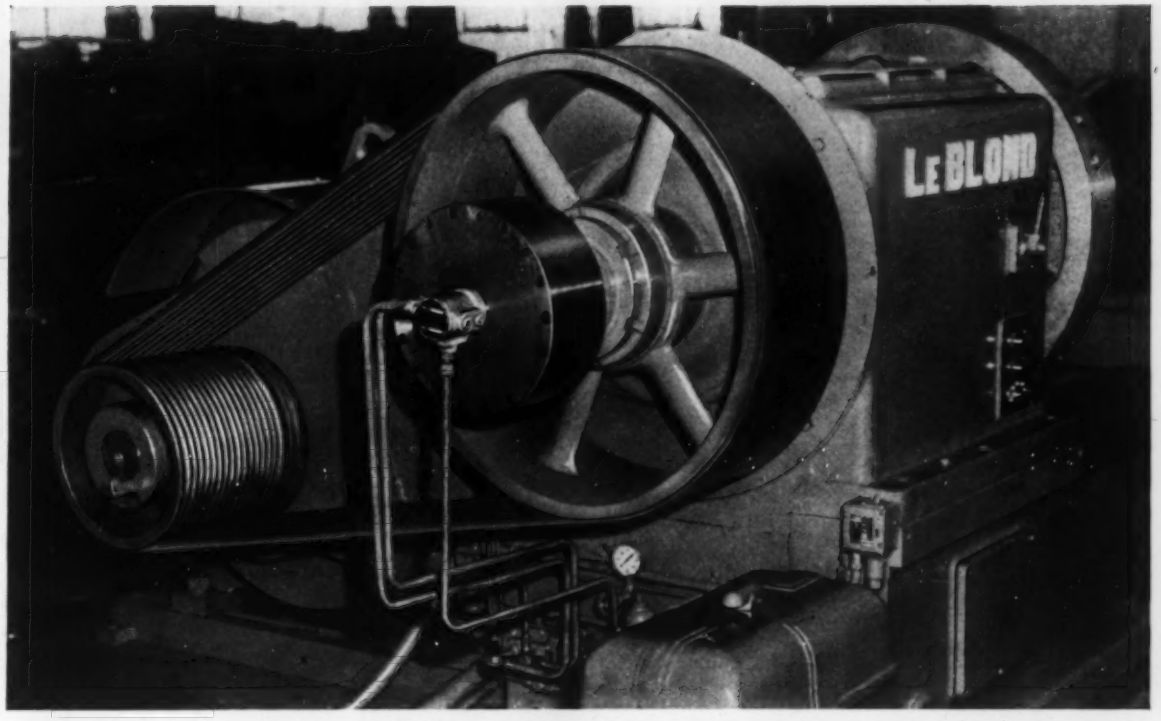
Moreover, resistance to moisture, oxidation and mechanical shock make LINEAR SILICONE "O" RINGS an excellent choice in many other modern sealing problems. They are precision molded to your exact specifications. Get the full facts now!

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 447 on page 19



NEW R/M *Poly-V*® *Drive*

Solves Seven Major Power Transmission Problems!

Heavy duty drive problems can be accepted as necessary and costly features of power driven equipment—or they can be overcome! The difference is Poly-V* Drive . . . R/M's patented new concept in heavy duty power transmission. Here's how R/M Poly-V Drive helps eliminate seven major problems common to most conventional V-belt drive applications.

BELT MATCHING—Poly-V employs a single unit, V-ribbed endless belt running on specially designed sheaves—not a series of V-belts which vary in length. Belt length matching problems are completely eliminated!

SPEED RATIOS—Full contact between belt ribs and sheave grooves prevents belt "sinking" and uneven speeds . . . maintains constant speed ratios and effective pitch diameter from *no* load to *full* load!

SPACE REQUIREMENTS—Greater horsepower capacity per inch of sheave width with Poly-V delivers up to 50% more power in the *same* space as a multiple V-belt drive . . . or *equal* power in as little as ⅔ the space!

DRIVE LIFE—Poly-V Drive has *twice* the contact area with only *half* the face pressure and that means *less* wear, *longer* life for both belt *and* sheaves!

STOCK INVENTORIES—Just *two* cross sections of Poly-V Belt meet *every* heavy duty power transmission requirement, as compared to *five* in the case of V-belts. With Poly-V you keep belt and sheave inventories to an all time low!

HEAT PROBLEMS—Because thinner Poly-V Belts have twice the ribbed area of V-belts exposed to the air, you are assured *cooler* operation and less strain on your equipment. And, of course, Poly-V Belt construction is heat resistant, oil-proof and non-spark!

EQUIPMENT DOWNTIME—Stronger, cooler running, longer lasting Poly-V Belt needs fewer tension adjustments after run-in . . . stays on the job longer to reduce downtime costs for replacements, too!

If any—or *all*—of these features can help improve your heavy duty power transmission drive performance and dependability, you owe it to yourself to investigate R/M Poly-V Drive. R/M engineers who developed it will be glad to assist you in determining the Poly-V Drive installation that will best solve your problems . . . give you "More Use per Dollar."

*Poly-V is a registered Raybestos-Manhattan trademark.

RM734

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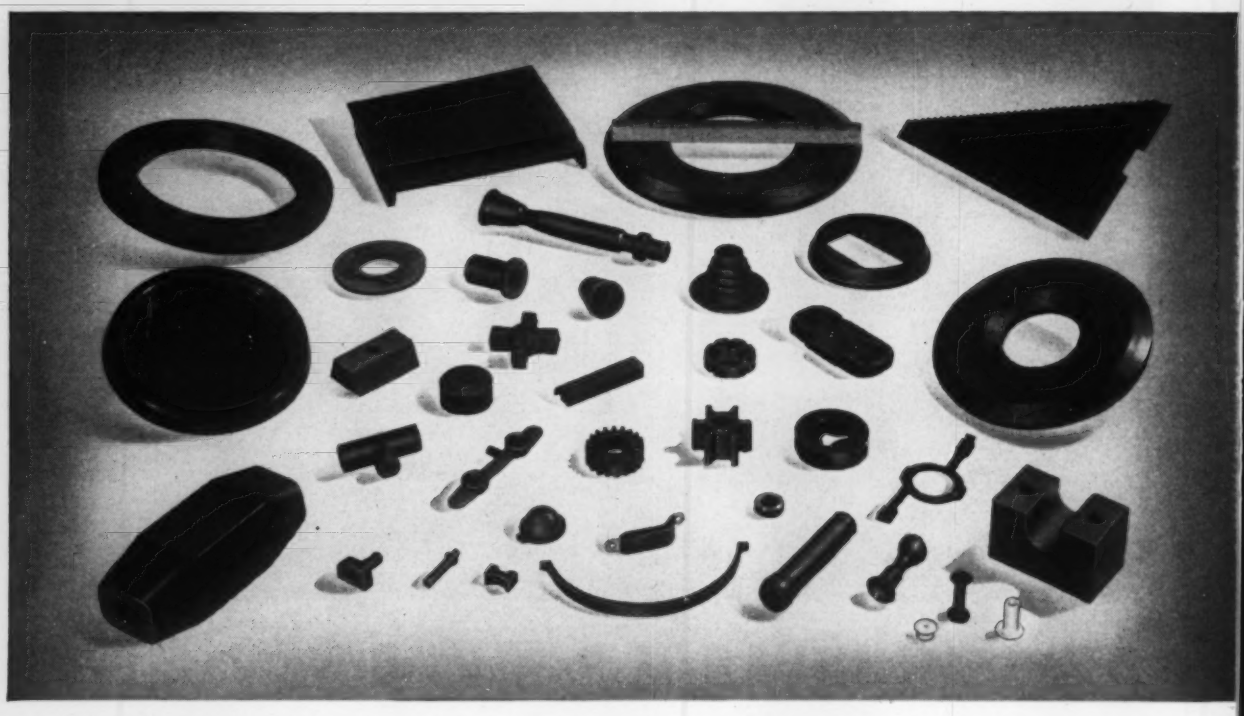

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Correct design and material of component parts can prove the solution to difficult product problems. Custom-Engineering molded parts to meet specific applications has been a specialty at Manhattan for over 60 years. R/M engineers design molded parts to meet new product requirements. They develop improved parts to overcome troublesome conditions or high production costs caused by parts and materials currently in use.

Natural rubber may be the best choice for your product components. Perhaps operating conditions dictate the use of an oil-proof or chemically resistant synthetic rubber. Or analysis of your requirements may suggest silicone will do a better job. R/M specialists will help you determine the *best* material . . . and follow through with the *best* design to assure long, trouble-free service regardless of temperature or other conditions. Manhattan's modern facilities for quality control, inspection, flash removal and precision manufacturing equipment give you the added advantage of low cost, mass production methods. You get the custom-engineered parts you need . . . delivered *in time* to meet production schedules.

The same engineering and production quality goes into cut and extruded parts made by R/M to your special order, as well as Parock oilless bearings for submerged light duty in any solution not harmful to rubber. Wherever your design calls for industrial rubber products . . . R/M hose, conveyor belts, transmission and V-belts, and R/M's new concept in power transmission, the Poly-V® Drive, as well as molded parts, offer the practical solution to your design and cost problems. Let R/M specialists work with you.

**Poly-V is a registered Raybestos-Manhattan trademark.*

For booklet shown, or other data, write, phone or wire:

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SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

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Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

Circle 449 on page 19

FOR HELP IN SOLVING YOUR PROBLEMS

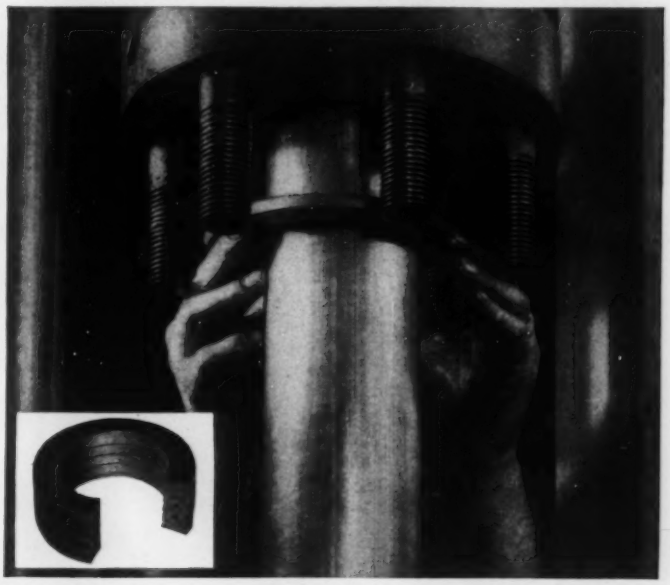
R/M VEE-FLEX...

for top performance under pressure

R/M Vee-Flex, the original convex-design hydraulic packing, is the best yet developed for tough applications. It is designed for every piston and rod, and is automatically self-sealing and self-adjusting, even at pressures of 6000 psi and above. Other features include precision molding and trimming; deep, thorough penetration of the compound into the fabric; rock-hard adapters to resist high pressures and to prevent extrusion.

If you have a packing problem, call on R/M's specialized packing engineering service. R/M makes a complete line of mechanical packings, and can also meet your requirements for "Teflon"* products and asbestos textiles.

**A Du Pont trade mark*



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PACKING DIVISION
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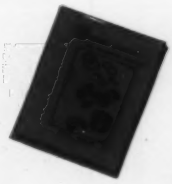

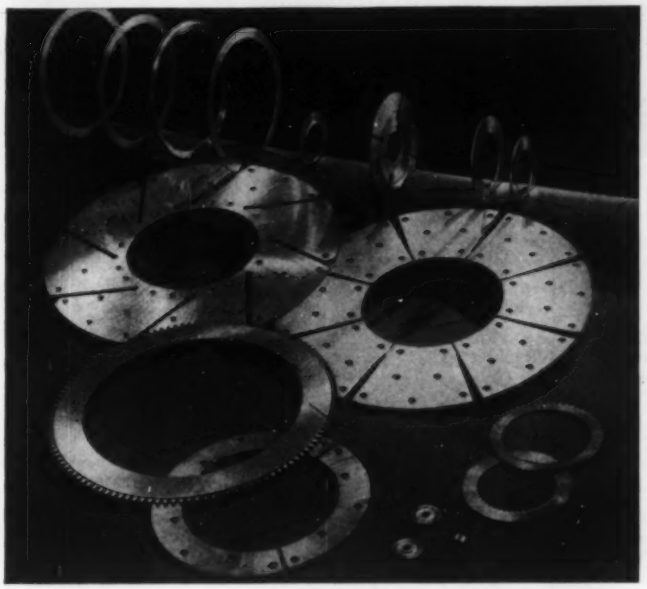

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Wherever high temperatures, close tolerances, or rapid repetitive engagement is a factor, R/M sintered metal friction parts may outperform asbestos. With their high thermal conductivity and absence of a destructible bond, sintered metals can give you greater output and longer wear.

This helps point up the advantage of turning any friction problem over to R/M. Unlike other manufacturers, R/M works with *all* kinds of friction materials ... from sintered metal to woven and molded asbestos, cork-cellulose and semi-metallic. So you can be sure of a completely unbiased recommendation whenever you consult an R/M engineer.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
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Teflon Tape, Packings, Sheets, Rods, Tubes

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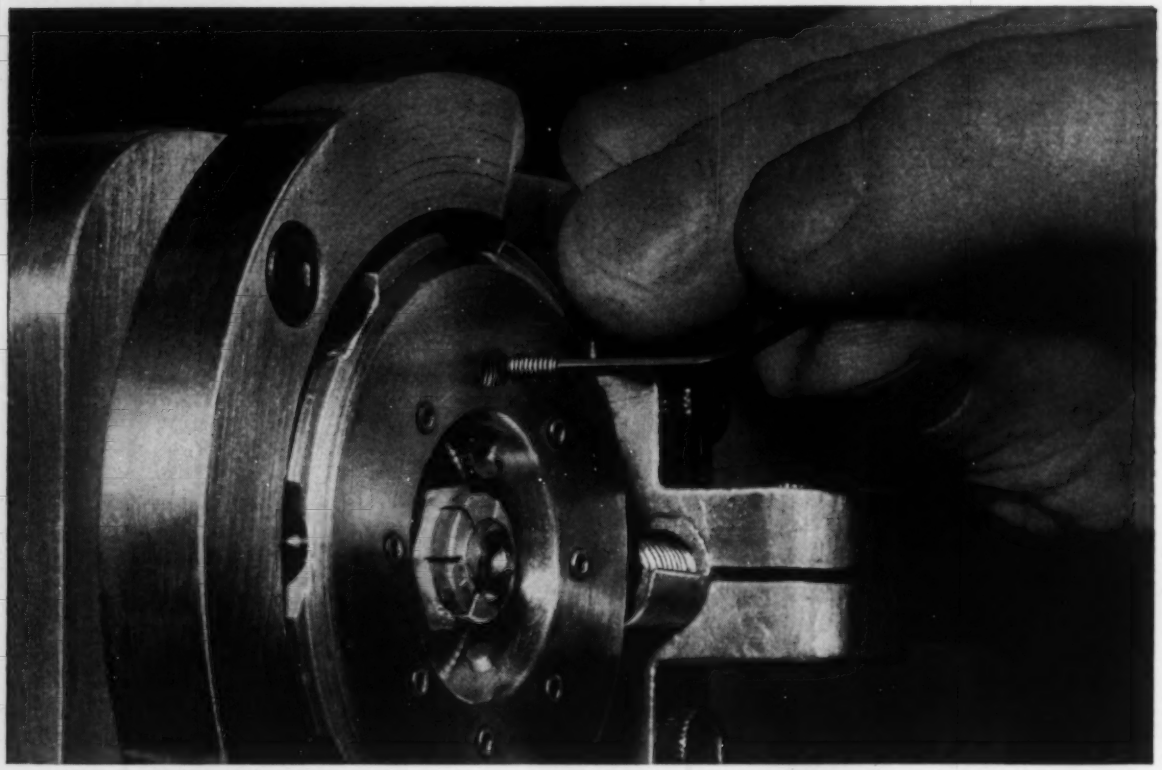


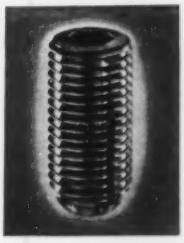
Microsize UNBRAKO socket screws simplify design problems—even in highly specialized equipment like this prototype precision loading device for use in advanced automated production operations.

Miniaturize with UNBRAKO set screws

HEAT-TREATED ALLOY STEEL*
PLAIN CUP POINT
Class 3 Fit Standard

Diameter		Threads per inch NC	Threads per inch NF	L Overall Length	Recommended Installation Torque in Inch-Pounds NC	Recommended Installation Torque in Inch-Pounds NF	Weight per Box of 100 in Pounds
#0	D .060 F .028	..	80	1/16	..	.5	.01
		..	80	3/32	..	.5	.01
		..	80	1/8	..	.5	.01
		..	80	5/32	..	.5	.01
		..	80	3/16	..	.5	.01
		..	80	1/4	..	.5	.01
#1	D .073 F .035	..	72	1/16	..	1.5	.02
		..	72	3/32	..	1.5	.02
		..	72	1/8	..	1.5	.02
		..	72	5/32	..	1.5	.02
		..	72	3/16	..	1.5	.02
		..	72	1/4	..	1.5	.02
#2	D .086 F .035	56	..	1/16	1.5	..	.03
		56	..	3/32	1.5	..	.03
		56	..	1/8	1.5	..	.03
		56	..	5/32	1.5	..	.03
		56	..	3/16	1.5	..	.03
		56	..	1/4	1.5	..	.03
#3	D .099 F .050	48	..	3/32	5.0	..	.04
		48	..	1/8	5.0	..	.04
		48	..	5/32	5.0	..	.04
		48	..	3/16	5.0	..	.04
		48	..	1/4	5.0	..	.04

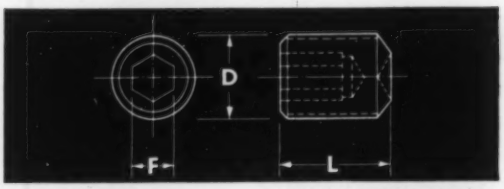
*Also available in stainless steel



You need not design special set screws to secure your new miniaturized equipment. Microsize UNBRAKOS were developed specifically for use in modern small devices.

UNBRAKO screws are made of carefully selected alloy steel. They are manufactured to timepiece precision. Sockets are deep and uniform for greatest wrench engagement and longest reuse. Threads are fully formed for maximum strength and exact fit. And UNBRAKOS are heat treated to the optimum condition for high tensile strength and ductility without brittleness or decarburization.

Ask your authorized industrial distributor about microsize UNBRAKO socket screws today. Or write us for Bulletin 2055 and samples. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.



STANDARD PRESSED STEEL CO.
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JENKINTOWN PENNSYLVANIA

good for MILLIONS

of operations in basic automation controls

WESTINGHOUSE CONTROL RELAYS

TYPE NH RELAY
UP TO SIX POLES
10 amp, 600 volts

Where long life and dependable relay control of electrical circuits are required, Westinghouse Type NH relays are ideal. They operate efficiently on low current from pushbutton stations, temperature or pressure devices, limit switches, photoelectric or other controls.

Case-hardened operating parts provide tough, wear-resisting surfaces for longer operating life. Knife-edged minimum friction bearings, prevent binding or delayed action. Circuit continuity is further guaranteed by neoprene shock-absorbing mounting. Fine silver contacts close with firm pressure, and low resistance.

All parts, including coils and cores, can be easily removed from front. Readily changeable for adapting to voltages through 600 volts.

Supplied in any combination of normally open or closed contacts . . . up to six poles. Combinations easily changeable in the field without additional parts.

YOU CAN BE SURE...IF IT'S Westinghouse

Type NH is one of a full line of Westinghouse relays.

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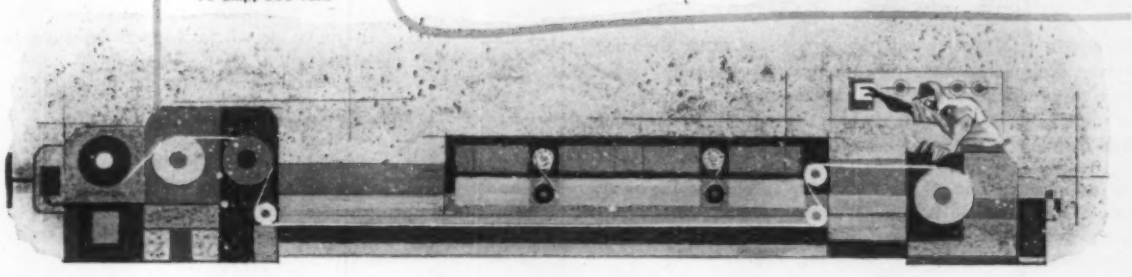
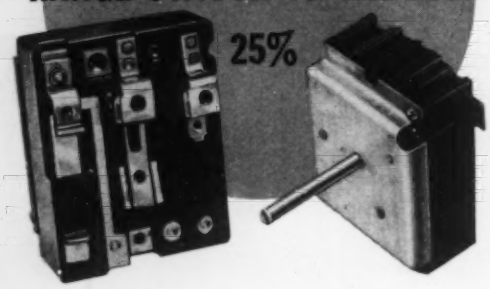


Circle 452 on page 19

(Advertisement)

Designed with... Beryllium Copper

SIZE OF PROCTOR ELECTRIC'S RANGE-SWITCH IS REDUCED 25%



In its line of fast heating range controls, Proctor specifies the beryllium copper alloy designated Berylco #10, supplied by The Beryllium Corporation, Reading, Penna. Proctor has discovered in this alloy a particularly ideal combination of physical properties—high fatigue strength, good resilience for spring uses, and excellent electrical conductivity for parts carrying current.

PROPERTIES OF "BERYLCO" 10 STRIP

(½ hard temper, heat treated)

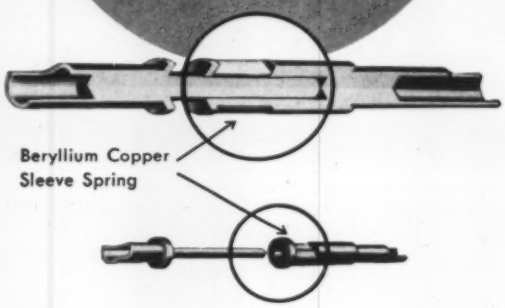
Tensile Strength	110,000 psi (minimum)
% Elongation in 2 in.	5 (minimum)
Rockwell Hardness	
B Scale	95 (minimum)
30T Scale	79 (minimum)
Electrical Conductivity	
% IACS	48 (minimum)
Elastic Modulus in Tension (20°C)	
Before heat treatment	16,000,000 psi
After heat treatment	18,000,000 psi
Elastic Modulus in Torsion (20°C)	
Before heat treatment	6,000,000 psi
After heat treatment	6,800,000 psi

The high tensile strength of beryllium copper eliminates the need for bulky and complicated forms in these parts, thereby permitting a 25% reduction in the unit's size over former models. While the beryllium copper parts constitute only 20% of the weight of the materials employed in the completed range-switch, they are rated 85% in importance by the manufacturer.

In addition to special test requirements of range manufacturers, each switch passes 300 quality control tests at Proctor. In a "mechanical abuse" test, for example, the control shaft is rotated 20,000 times, after which the unit must still operate and maintain its calibration within ±2%.

A technical bulletin (#37), with more specific details on the design and use of beryllium copper for Proctor electric range-switches, is available without charge upon request to The Beryllium Corporation, Reading, Penna.

SLEEVE SPRING IN CANNON PLUG PRESSURES FOR MAXIMUM CURRENT FLOW



The sleeve spring in a Cannon multi-contact electrical connector forces the pin of the plug tightly against the socket wall to assure maximum consistent current flow. The fatigue strength of the metal used in the spring governs the efficiency and life expectancy of the entire connector. The spring metal must be corrosion resistant, since corrosion would weaken the metal, shortening the life of the spring, and cause wear on the pin of the plug.

In laboratory tests, engaging and separation forces were measured on both beryllium copper and phosphor bronze socket springs when subjected to bending torque from a special test prod. The separation force values after distortion were much lower for the phosphor bronze springs than for the beryllium copper springs. In fact, the phosphor bronze springs failed a number of times, but the beryllium copper springs, made of Berylco #25 alloy, provided consistent pressure even after having been split wide open.

Cannon Electric formerly used phosphor bronze as the spring metal until it conducted tests with beryllium copper. Now Cannon expects to make beryllium copper the standard 'napkin ring' metal on all of its connectors.

A technical bulletin (#34) is available without cost from The Beryllium Corporation, Reading, Penna. It describes in detail the numerous tests used by Cannon Electric in evaluating beryllium copper as a material for the sleeve springs of its multi-contact connectors.

Circle 453 on page 19

MACHINE DESIGN
MARCH 7, 1957

The Third Dimension

ARE YOU a three-dimensional engineer? According to AT & T President Frederick R. Kappel, who recently addressed the AIEE on the subject, the dimensions of such an engineer are measured by these parameters:

The first dimension is acquired in college, where an engineer learns how to move in a straight line in a particular field.

The second dimension, breadth, comes from continued training and self-study that both broaden a man and keep him up to date, so he can solve problems in new and broader areas of engineering.

The third dimension is the height that comes from mingling engineering and management ideas so that the engineer's understanding of the problems and requirements of the business makes him more effective in the business.

This understanding comes not only from study but from shoulder-to-shoulder contact with operating, financial and merchandising people. And to insure a volume effect this third dimension is needed everywhere—not just here and there—among engineers. Mr. Kappel concludes that if engineering is to be solid, it must have this volume.

It might be added that this volume is a dynamic quantity that can change in any or all of its dimensions. Thus, if the first dimension shrinks from neglect or the second is not enlarged to its full potential, the base for developing the third is too small to produce an adequate volume effect.

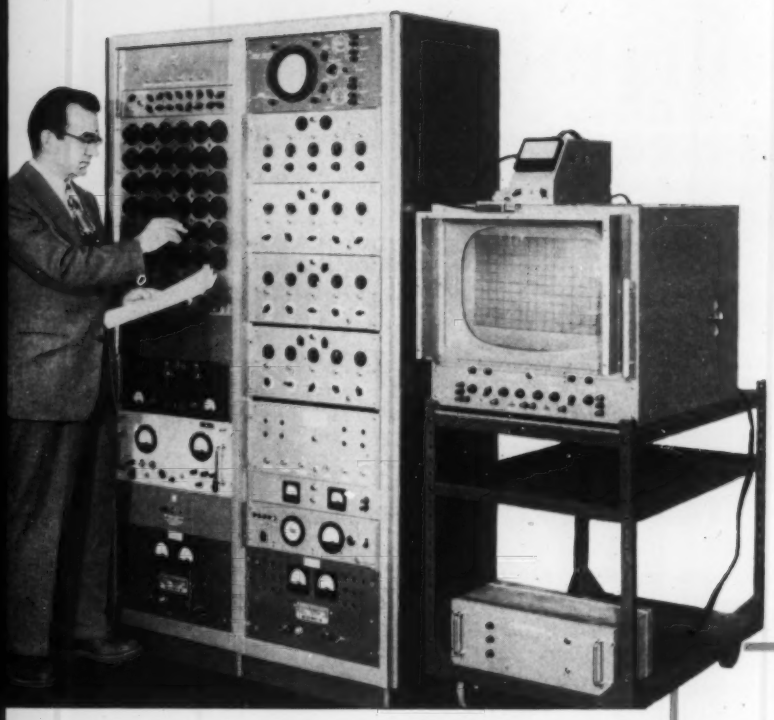
Fortunate indeed is that company whose engineers, by applying their talents and seizing their opportunities, have built up their first two dimensions to a high degree.

But keeping plants in flats in the basement doesn't help them bear fruit. And circumscribing the activities of engineers in purely technical channels won't result in three-dimensional engineers.

Management's No. 1 concern therefore must be to provide the soil and climate for engineers to grow in the third dimension. With engineers whose thinking is not bounded by the technical horizon but reaches toward the stars, a business need never fear for its future.

Colin Carmichael

EDITOR



Designing with

By L. Sigfred Linderoth Jr.
Professor of Mechanical Engineering
Iowa State College
Ames, Iowa

ELECTRONIC and mechanical computers, both large and small, have been used for many years in scientific computations and certain areas of engineering. In recent years, there has been an increasing awareness of the usefulness of these machines as an aid in design. High-speed, automatic electronic computers make possible more rigorous analyses of strength and performance of machine elements and assemblies. As a result, optimum designs are usually determined easier and faster than by rule-of-thumb practices. Engineering department capacities can be extended through the use of both analog and digital electronic computers if qualified personnel are available to program and operate them.

This article summarizes considerations in using computers in design and presents a number of typical problems in which computers can be applied. An earlier article, entitled "Digital Computers in Design" by Marshall Middleton Jr. in MACHINE DESIGN dated Feb. 23, 1956, showed how computers are used in the design of lines of equipment that are built from a variety of components, many of them standard, to satisfy a variety of performance requirements.

Basic Computers: The slide rule is a computer of inestimable value in spite of its limitations. It serves the designer well, since many equations

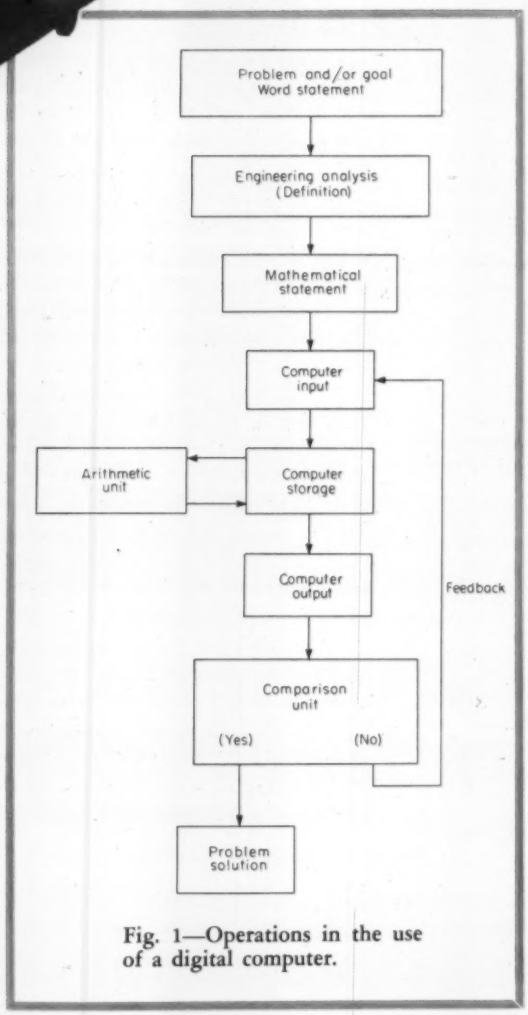


Fig. 1—Operations in the use of a digital computer.

High-Speed Electronic Computers

. . . permits rapid determinations of optimum designs and extends engineering department capacity.

are products or exponential functions well suited to slide-rule computation.

When a larger number of significant figures are needed than the slide rule will yield, the designer turns to the mechanical digital computer or desk calculator. This machine is capable only of addition and subtraction and the corollary func-

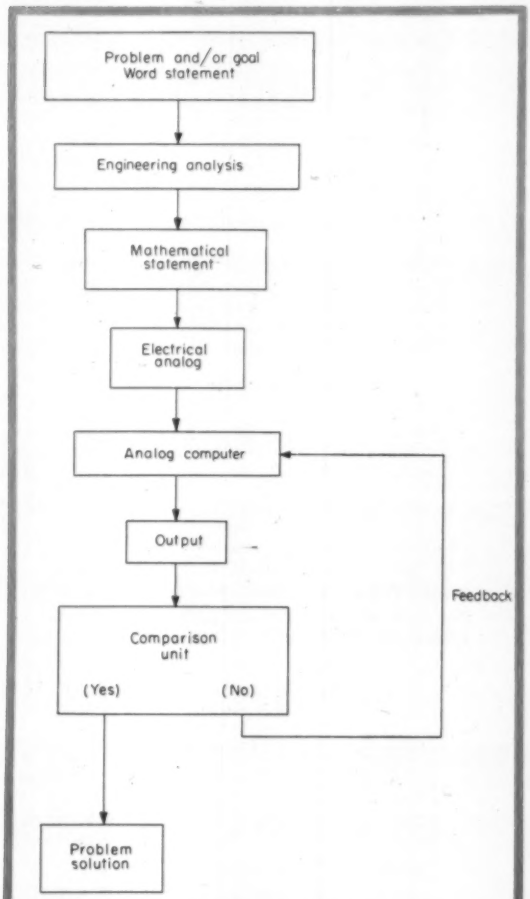


Fig. 2—Operations in the use of an analog computer.

Typical Applications

Valve-Gear Design

A common problem in the design of valve operating linkage for internal-combustion engines arises from the elasticity of the components. At low speed the valve follows the cam follower with little or no lag or lead, but at high speeds the inertia of the parts causes deflections in push rods and rocker arms, and the valve no longer follows the follower motion. The degree of error is a function of the stiffness of the components, and the designer must anticipate this error and modify the cam profile to get correct timing of the valve. This in turn may cause excessive acceleration loads on the follower beyond the ability of the material to stand up for the required life. Fig. 1*a* shows a typical case.

A compromise is in order. The electronic digital computer may offer the means to a solution. It can be programmed to solve the appropriate differential equation with parameters

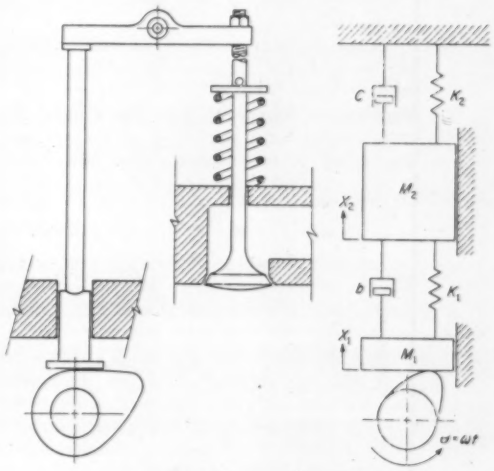


Fig. 1*a*—Typical valve operating linkage for internal combustion engine and kinematic equivalent diagram.

tions of multiplication and division. In the newer models some memory or storage capacity is available. But in spite of recent improvements, the desk calculator can still provide only direct solutions. It cannot go back and try again unless the operator causes it to do so by erasing the problem or part of it and starting over with new data.

Automatic Electronic Computers: Automatic computers can help make design decisions by supplying facts and data through their ability to complete calculations at high speed and to compare answers automatically with problem requirements. They can change constants and parameters until the best or ultimate solution is obtained. Operations in the use of computers are illustrated by the block diagrams, Fig. 1 and Fig. 2.

As the first step in the diagram procedures, the problem and/or goal is studied and an engineering analysis is made. This usually takes one of two forms: (1) a rigorous or theoretical analysis or (2) an experimental approach using full-size or

Typical Applications (*Cont'd.*)

representing the profile modifications. For each solution the computer can check the forces and stresses on all members. The output is a series of curves showing the error of valve travel, the modified cam profile and the force on the follower. With these data the designer can then choose the best compromise.

Cam Design

A typical cam problem may require a slide motion through a distance L in time T with a dwell before and after the event, Fig. 2*a*. A further specification may be a minimum cam load for the mass M and zero acceleration at the beginning and end. (See John A. Hrones—"Key Factors in Cam Design and Application," MACHINE DESIGN, Vol. 21, No. 4, April 1949, Page 127.)

Curves that will give cam profiles to meet the specifications are the cycloid, certain polynomials and certain composite curves, Fig. 3*a*.

To find the minimum force requires a plot of each acceleration curve with time. This is relatively easy for the cycloid and the polynomial since their second derivatives with respect to time yield continuous curves throughout time T. These can be plotted to determine the maximum value of the acceleration. The composite curve requires optimizing, and here the computer can be of value.

In the illustration, the composite curve is made up of a cubic curve (third-order polynomial) and gravity (second-order polynomial). The problem is where to join the curves—that is, what values of t_1 and t_2, t_3 and t_4 to use. The symmetry of the chosen curves helps this solu-

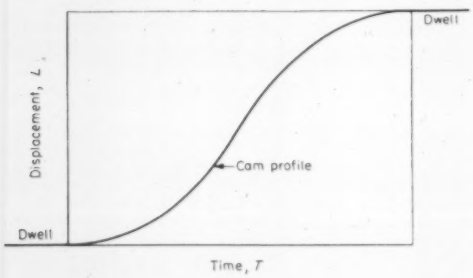


Fig. 2*a*—Typical specification for motion of a slide which has displacement L in time T.

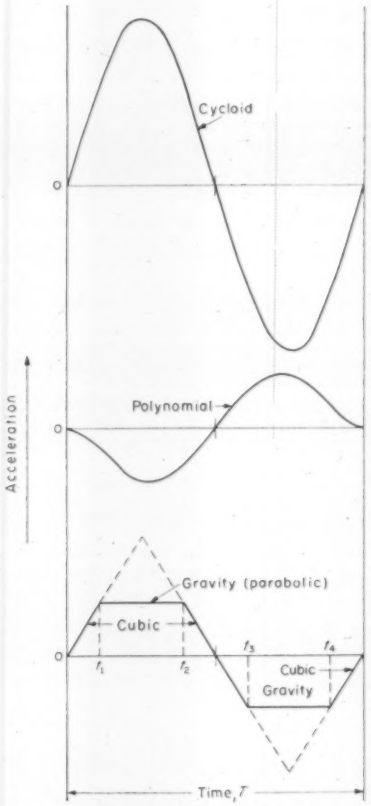


Fig. 3*a*—Specified slide motion can be obtained from a cam with profile derived from the cycloid curve, certain polynomials or certain composite curves.

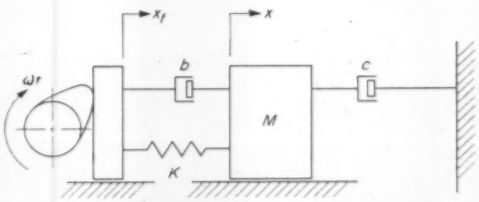


Fig. 4*a*—Kinematic equivalent of a cam-driven slide.

scale models to establish data. Either method should result in a mathematical statement that can serve as input to a computer.

The conversion of the mathematical statement of a problem to a form that a computer can accept is called *programming*. This step may be progressively simplified because sub-routines can be stored for use in later problem solutions. Various engineering groups will require different types of routines, but the electronic computers have become very versatile and can handle almost any problems up to the limit of their storage capacity. Programming then involves a knowledge of the routines available and their proper selection to fit the solution of the problem at hand.

Next on the block diagrams is the computer proper where the analysis or computation is actually carried out. Its output is compared either automatically or visually with the desired answer or goal, if such comparison is required. Judgment tion but does not minimize the amount of calculating required.

A kinematically equivalent or schematic linkage represents the cam problem, Fig. 4*a*. The resulting equation of equilibrium is:

$$M\frac{d^2x}{dt^2} + (b + c)\frac{dx}{dt} + Kx = b\frac{dx_f}{dt} + Kx_f$$

where $x_f = f(\omega t)$, M is the mass to be given motion by the cam, K is the equivalent spring rate of the system, which can be determined, x_f represents the follower motion in time t, x represents the corresponding motion or displacement of the mass M, b is the damping constant between the follower and the mass, and c is the damping constant between the mass and the machine frame. The solution of this equation can be performed readily on a suitable analog computer.

Fluid-Dynamics Analysis

In analyzing the behavior of the load actuated by a hydraulic piston actuator, Fig. 5*a*, the following differential equation resulted:

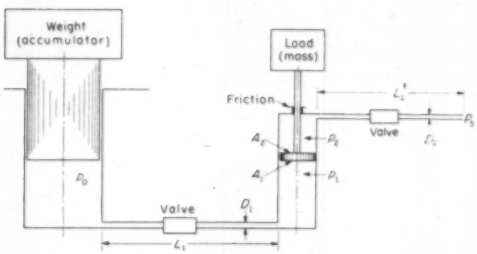


Fig. 5*a*—Load actuated by a hydraulic piston.

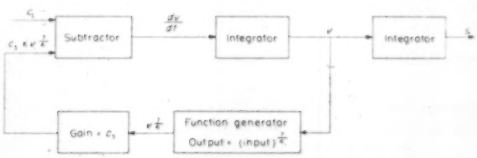


Fig. 6*a*—Block diagram illustrates use of analog computer in solving equation for hydraulic circuit.

$$\frac{dV}{dt} = C_1 - C_3 V^{7/4}$$

This expression did not lend itself to analytical integration, and in order to get a solution a graphical method was used. (See L. Sigfred Linderoth Jr.—"Displacement Versus Time Characteristics of Hydraulic Actuators," Paper No. 50-SA-5, *Trans. ASME*, Feb., 1951.) J. L. Shearer of M.I.T. proposed the use of an analog computer for this type of problem and included the block diagram in Fig. 6*a* to illustrate the method of solution. This is an excellent example of a nonlinear differential equation.

Journal-Bearing Design

A compromise type of problem is that of designing a plain journal bearing for hydrodynamic operation. There are nine basic variables in the problem. The question facing the designer is one of choosing the best combination to fit the dimensional and other restrictions in his design. In addition to the nine basic variables the problem of end leakage and oil supply enters the computation.

Present solution method is to fix certain variables arbitrarily and solve for the final one. Optimum conditions in the bearing design can be defined in terms of temperature of oil, minimum clearance between journal and bearing, and length-diameter ratio, or perhaps simply with minimum friction or maximum load capacity. Then a suitable program can be written for a "line" of bearings of varying capacity. Subroutines of the Sommerfeld equation and the Kingsbury leakage factor could be stored in the computer and applied to any bearing problem.

Gear Design

Equations for the strength and wear resistance of gear teeth are well established in terms of the geometry of the gear and the physical properties of the materials involved. Less well established are the equations for determining the actual loads on the teeth. These are the so-called dynamic load equations. They vary from rule-of-thumb multipliers to the complex Buckingham equation.

A proper relation between the equations for wear load, transmitted load (dynamic load) and bending strength must exist or the gear will experience early failure. After a choice of ma-

is exercised to show whether the answer is acceptable or unacceptable. In the latter case, adjustments are made and a new solution is produced.

A complete computer has four basic sections: input, storage, computing section, and output or display. The input unit may use a keyboard, punched tape, magnetic tape, punched cards or, on the analog computer, a "patch board." The storage section may use magnetic tape, a magnetic drum, or magnetic cores. The output may be magnetic or punched tape, punched cards, a cathode-ray tube display, a galvanometer recording or printed paper.

It is necessary, of course, for the design engineer to know the capabilities of the computing equipment if he is to make maximum use of it. Engineering departments sufficiently large to afford computer facilities will usually have staff members available who have both the knowledge and skill to do the programming and advise the designer of the equipment capabilities and limitations. Small engineering and design groups can use one of the several computer facilities that accept problems on a fee basis. These computer

Typical Applications (*Cont'd.*)

terials has been made, the remaining variables all refer to the geometry of the gears. There is no single answer or best solution.

The use of a computer with proper programming might give a series of acceptable relationships between the pitch diameters, diametral pitch, width, pressure angle and other features. Then, based on available space or other limiting factors such as pitch-line velocity, the designer could make a proper choice for his design.

Curved-Beam Calculations

The design of curved beams in press frames and machine components should be greatly simplified by use of digital computing techniques. Again the problem is one of making the best use of material to bring about a minimum stress under a given load.

The problem resolves into a decision as to what is the best section shape at the point of maximum curvature and how the metal should be distributed in this section. The curved-beam equations, if the assumptions used in ther derivation are accepted as being valid, are quite rigorous, but they leave a difficult integral to evaluate.

The evaluation usually consists of a converging series which is easy to handle on a digital computer. It should then be possible to try a number of sections to check and find the one giving the lowest stress for a given load and a minimum weight of section.

Bearing-Load Calculations

One of the most time-consuming, although relatively simple calculations made in the design of internal combustion engines is the load diagram for the journal bearings of the crank and main bearings. Fig. 7*a* illustrates the forces in the engine mechanism. The equation for the force q on the crank and main bearings from gas pressure p and inertia force p_i is:

$$q = \frac{p_t \left(\frac{L}{R} \right)}{\left[\left(\frac{L}{R} \right)^2 - \sin^2 \theta \right]^{1/2}}$$

where $p_t = p + p_i$. The forces are expressed as psi of piston area. Results apply to any engine of rod length to crank radius L/R.

The gas pressure in the cylinder can be approximated by the method used by Shaw and Macks in the text "Analysis and Lubrication of Bearings," McGraw-Hill Book Co. The idealized pV diagram is shown in Fig 8*a* and the equation for establishing the value of the expansion pressure p_4 at the bottom dead center is:

$$p_4 = \frac{(n-1)(r-1)}{(r^n - r)} p_m + p_1$$

where n is the exponent of V in the expansion and compression curves for which pV^n is constant, r is the engine compression ratio, p_m is the indicated mean effective pressure, and p_1 is the initial pressure in the cylinder.

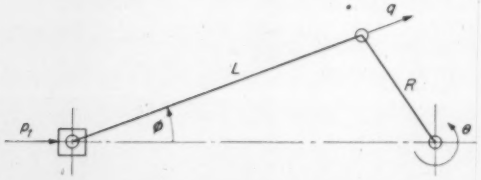


Fig. 7*a*—Loads on the crank and main bearings of an internal combustion engine.

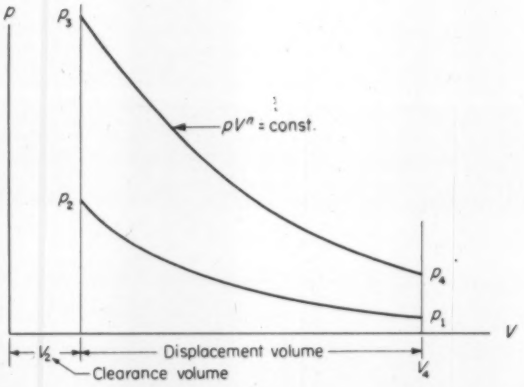


Fig. 8*a*—Idealized pV diagram for internal combustion engine illustrates sources of pressures from which bearing loads are derived.

groups usually offer instructions in programming, and some of them do the programming.

Computer Capabilities: To a great extent design is still an art. It often deals with creative problems not rigorously subject to science and logic. Human decisions are required for the proper solution of problems, and to this extent design can never be completely automatized.

To what extent, then, can computers be helpful in design? Computers operate on problems that can be expressed as mathematical equations. Main categories of these are rigorous or theoretical solutions and expressions based on empirical data.

How rigorous are the so-called rigorous equations? Many assumptions made in their derivation are the result of mathematical obstacles and make the equations valid only within certain limits. Consider the beam equation $s = MC/I$. This equation is good only if the section is uniform throughout the beam and the applied loads are simple in their distribution. This type of beam is seldom used in design, so here is a possible opportunity to make more realistic assumptions govern the form of the equation and use a computer to overcome the resulting complexities.

Differential equations of the dynamic behavior of mechanisms which follow Newton's laws of motion and include damping factors are frequently amenable only to approximate solutions. The electronic digital or analog computer offers a ready means for solving such equations to any degree of accuracy desired.

This equation can be set up as a subroutine and the various values of n, r, p_m and p_1 can be entered into the computer for the specific engine in mind, thus establishing a value for p_4.

With p_4, the exponent n used in calculating it, and the volume V_4 at the bottom dead-center position ($\theta = 180$ degrees), a value for the constant can be established and the value of p at any volume V for this particular engine calculated. Volume V is calculated from the subroutine indicated by the equation for V in terms of L/R and θ.

Fig. 9*a* is a computer block diagram for this series of calculations. If a pV diagram for an engine similar to the one contemplated is available, it will give more reliable results than the method of using the idealized diagram. Results from the idealized diagram tend to be on the high side, thus leading to a conservative design.

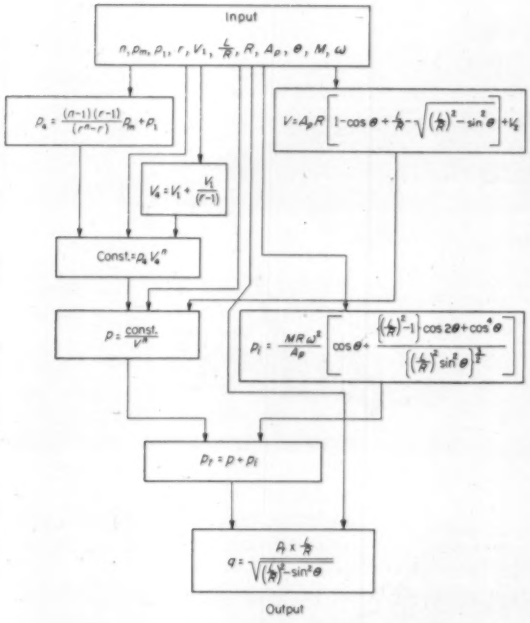

Input
$n, p_m, p_1, r, V_1, \frac{L}{R}, R, A_p, \theta, M, \omega$
$p_4 = \frac{(n-1)(r-1)}{(r^n-r)} p_m + p_1$
$V = A_p R \left[1 - \cos\theta + \frac{L}{R} - \sqrt{\left(\frac{L}{R}\right)^2 - \sin^2\theta}\right] + V_c$
$V_4 = V_1 + \frac{V_1}{(r-1)}$
Const $= p_4 V_4^n$
$p = \frac{\text{const.}}{V^n}$
$p_i = \frac{MR\omega^2}{A_p}\left[\cos\theta + \frac{\left(\frac{L}{R}\right)^2 - 1\cos 2\theta + \cos^4\theta}{\left(\frac{L}{R}\right)^2 \sin^2\theta}\right]^{\frac{1}{2}}$
$p_f = p + p_i$
$q = \frac{A_i \times \frac{L}{R}}{\sqrt{\left(\frac{L}{R}\right)^2 - \sin^2\theta}}$
Output

Fig. 9*a*—Computer block diagram for determining loads on crank and main bearing of internal combustion engine.

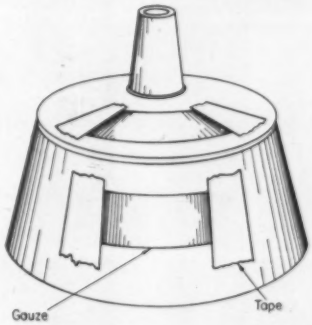
Curve Fitting . . .

In the article "Fitting Equations to Experimental Data" (MACHINE DESIGN, January 24, 1957, Page 95), the author has called attention to an error in the relationship of s_u to T as expressed by Equations 13, 14 and 15. Quantities T, T^2 and T^3 in these equations should appear as products of the constants (BT, CT^2, DT^3) and not in the denominator as shown.

Tips and Techniques

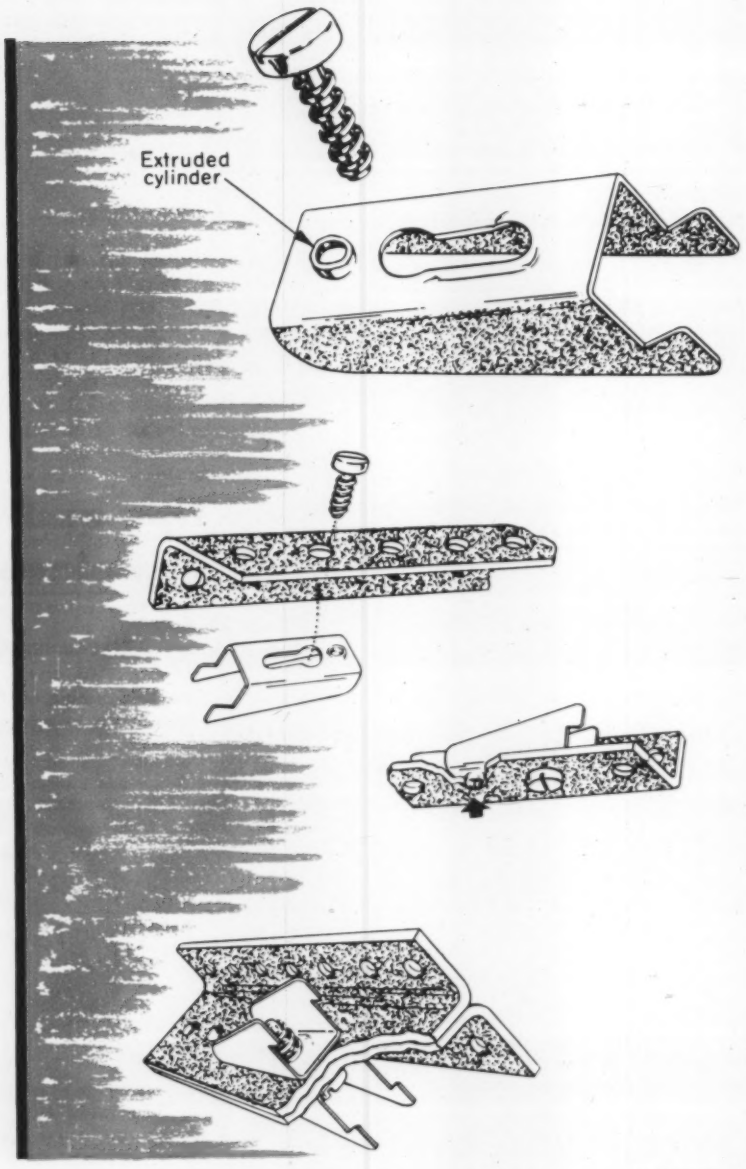
Preventing Graphite Smudges

Graphite smudges from freshly-sharpened pencils can be a nuisance. A gauze pad taped to the

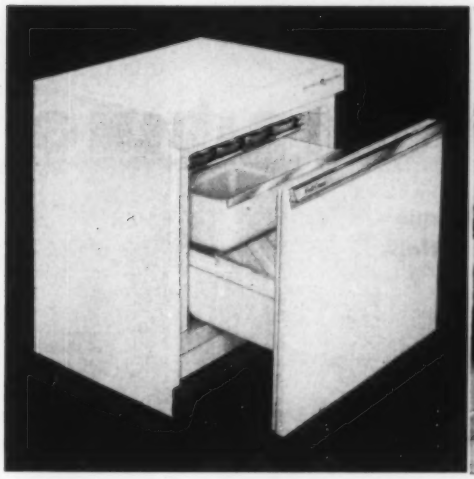


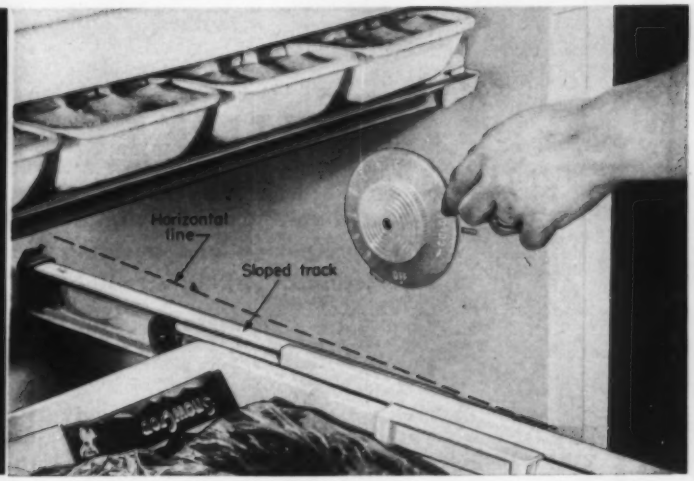
pencil sharpener or close to it makes a handy wiper to prevent this.—JOSEPH J. PACSAY, *Barkley & Dexter Inc., Fitchburg, Mass.*

scanning the field for Ideas

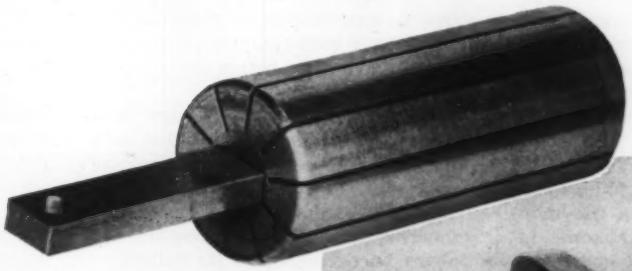


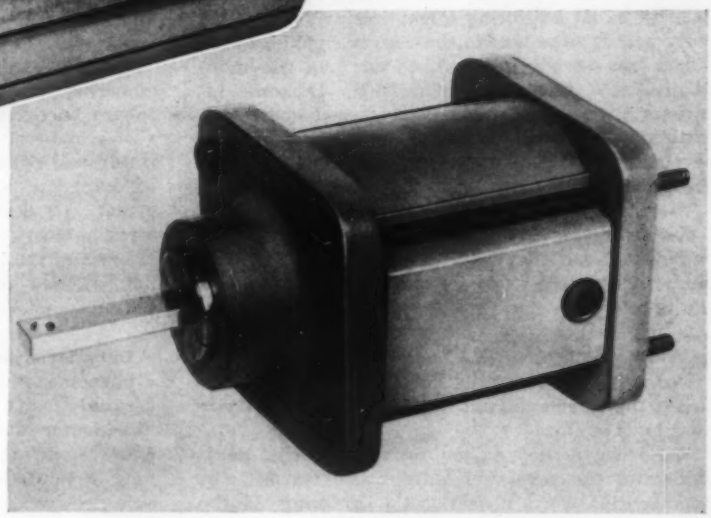
ACCURATE ALIGNMENT OF METAL-TO-METAL ASSEMBLIES is provided by a clip designed with a cylindrical extruded element. The keyhole slot in the clip is designed to slip over the threads of a screw type fastener. The small extruded cylinder on the clip fits into a hole on a subassembly serving to prevent rotation of the clip and to add to its load-carrying capacity. The design was developed by the Berger Div. of Republic Steel Corp. for fastening clip type convertible shelving.





AUTOMATIC CLOSING OF DRAWERS in General Electric Roll-Out freezers is provided by inclined mounting of drawer roller tracks. With the tracks sloped downward slightly from front to back, weight of the food causes the drawers to roll shut automatically. A soft fiber-glass filled, vinyl-plastic gasket around the inside of the drawer front assures positive sealing.





SLOTTED ONE-PIECE ARMATURE in ac push and pull type solenoids provides an extremely rugged mechanical construction and meets electrical design and operating requirements. The slots sufficiently reduce eddy currents formed in the armature by the coil field to assure fast operation and low heating of the solenoid. Developed by Black and Webster Inc., the solenoid plunger and extension are highly polished to minimize wear and assure long life in the unit.

Do you have a novel design idea for our other readers? You can receive ten dollars or more for each idea accepted for exclusive publication in this department. Send a short description plus drawings or photos to: "Scanning the Field for Ideas." MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

ENGINEERING WRITING

. . . a new "danger-signal" technique for recognizing and avoiding the pitfalls of technical writing

"HANG the reports. On with design!" This attitude toward writing seems to prevail in engineering departments. One reason that a technically trained person is reluctant to write is that he finds editing difficult—unnecessarily difficult because very likely he was never taught the rudiments of the process. If, instead, he was instructed only in grammar and style, the result may very well be writing that is freighted with gobbledygook.

Technical writing can be pruned of gobbledygook as easily as drawing a fillet, and this will clarify it as much as a fillet strengthens a corner. All that is needed is editing according to danger signals. The following illustrates an elementary danger signal: "Bisect the angle *into two parts.*" Obviously the words in italics can be deleted without affecting meaning—the danger signal is redundancy.

Redundancy, indecisiveness and other danger signals are discussed in this article. Each category is represented in the check list on the following page, containing examples of poor writing commonly found in technical literature. This check list will assist in editing a manuscript or draft.

By paying attention to the danger signals, an engineer can become his own editor, and can more readily spot flaws in engineering. In some instances a writer unfamiliar with a product has discovered engineering errors in it primarily because he could see through the poor writing concealing the error.

Redundancy: It has been said repeatedly (for emphasis) that emphasis is gained by repetition, but it is offensive to see a statement like, "Mount the device on a horizontally level surface." Does this mean that a special mounting procedure is necessary, or that a very accurate level is required (if so, what accuracy)? There would be no question if the command read simply, "Mount the device on a level surface."

Emphasis is not gained by redundancy; paradoxically, the reverse is often true because the nonessential word obscures the meaning of the basic word.

Superfluity: Recently this writer attempted to diagnose an obviously ailing report. The diagnosis was simple superfluity, particularly repetition of the superfluous word "use." Phrases like *"the use of* 2-inch pipe is recommended" were abundant. The words in italics can be deleted without affecting meaning. The difference in meaning between redundancy and superfluity is that the former repeats a thought, and the latter has no thought.

Superfluous words only pad writing with useless filler so that the punch of the idea is absorbed and deadened.

Vitiated Verbs: Verbs evolved in the language to voice action. When expressed passively, a verb becomes vitiated, or rendered ineffective, and the writing is not vigorous.

A maintenance manual contained the statement, "Use a screwdriver to separate the disks." This should have been written, "Separate the disks with a screwdriver," or better yet, "Pry the disks apart with a screwdriver."

The word "use" is a danger signal indicating either a superfluity or a vitiated verb. Words ending in "tion" also often signal a vitiated verb (e.g., perform the lubrication operation).

Verbs should be active wherever possible. Engineering is an active profession, and this activity should be expressed to its fullest.

Slipshod Synonyms: Too often a report is dashed off with words like perpendicular when normal is meant. Or perhaps a writer says stress instead of strain. These pairs of words are among the many that snare the unaware. The technical writer must not be lulled into laxity by the similarity in meaning or sound between words.

Indecisiveness: If the writer can't decide whether a phenomenon occurs or tends to occur, the reader certainly can't decide for him. An example is, "The motor tends to overheat when it is overloaded. However, it appears that a certain amount of running at limited overload conditions may be acceptable provided that the duration of the overload is minimized." If no more than this is known, it would be better not to mention it. But if a few facts are at hand, they would be useful presented in the following way: "It is estimated that the motor can stand

to eliminate gobbledygook

By Gibson A. Cederborg

Engineering Writer
Brown Instruments Div.
Minneapolis-Honeywell Regulator Co.
Philadelphia

Danger Signals—

Examples of Words and Phrases That Hinder Effective Writing

Redundancy

damping dashpot
horizontally level
aluminum *metal*
retract *upward*
uniformly consistent
properly tuned
two cubic feet *in volume*
read *through*
engage *with each other*
ac *current*
center *portion*
maximum *possible*
electrically and physically identical
value *and importance of*
assemble, fuse, attach *together*
time interval
innumerable *number of*
red *in color*
open, closed *position*
hexagonal *in shape*
close proximity
recoil *back*
range *all the way* from
coil *winding*
actual experience
between *the limits of* A and B
final outcome
physical size
balance *against each other*
cancel *out*
close *off*
open *up*
contains *within*

Superfluity

numerals *are used to* identify
preservation by *use of* salt
the spring *used* in the shock mount
the device *in question*
the marks *provided* on the chart
may *result in* damage *to* the
will not *properly* align
overspeed is *a* critical *factor*
stop any leaks *that are discovered*
failure *if and when it occurs*
turn the screw *when required* for adjustment
a potentiometer is *defined as*
the factor of radiation is important
formed by *virtue of*
motor *itself* was mounted
the adjustments *provided* on the device
after installation of the rheostat *has been completed*
it is quite possible that the device may
gasket *located* inside the
after *completion of an* assembly
convert *over* to
by a *device known as a* chronograph
by *means of* integration
read and record
must be lowered *in order* to get a proper reading

Vitiated Verbs

Vitiated	Forceful
provides continuous indication of	continuously indicates
permits the reduction of	reduces
obtain dynamic balance by	dynamically balance by
make a calibration	calibrate
perform the measurement	measure
makes for better heat distribution	distributes heat better
density measurement is made by	density is measured by
adjust parallelism	parallel
to produce deliberate cycling of	to cycle deliberately
if oscillation of the pointer occurs	if the pointer oscillates
helps in the production of	helps to produce
perform the lubrication operation	lubricate
by exerting a twisting action	by twisting
do not put kinks or bends in	do not kink or bend
functions to transmit	transmits
operates to correct	corrects
make the adjustment	adjust
is used to control	controls
is used in preference to	is preferable to
it should be remembered that	remember that

Slipshod Synonyms

stress, strain
normal, perpendicular
calibrate, adjust
constriction, restriction
transitory, transient
anhydrous, hygroscopic
replace, reinstall
resistor, rheostat
maximum, optimum
refraction, diffraction
affect, effect
adhere, cohere, stick
absorb, adsorb
preclude, prevent
capacity, capacitance
transparent, translucent
round, spherical, circular
emf, voltage, potential
ambient, atmospheric
adapt, adopt
corrode, erode
homogeneous, homogenous
altitude, elevation

Indecisiveness

evidently	may, might
tends to	considerably
appears to	excessive
seems to	sufficient
negligible	suitable
rather	various
reasonably	more or less
approximate	fairly
nearly	

Verbosity

Verbose	Terse
care must be exercised; use care not to; caution must be observed	be careful, don't
moisture content of air	humidity
large number of	many
it is imperative that	be sure that
the parts in some instances were defective	some parts were defective
taken into consideration	considered
is provided with; is equipped with	has, contains
through the medium of; along the lines of	by
in the nature of	like
advisable that a study be made of	advisable to study
for the reason that; on the grounds that	because, since
in the course of	while, during
in the event that	if

Showiness

Pretentious	Simple
terminate	stop, end
optimum	best
oxidization	oxidation
preventative	preventive
institute	begin
initiate	start
elevated	high
inexpensive	cheap
initial	first
purchase	buy
expense	cost
facilitate	ease, simplify
demonstrate	show
operate	run
subsequent	next
procure	get
expedite	hasten, speed
prior to	before
numerous; innumerable number of	many
abnormal indication	trouble symptom
investigate	study
excessive amount	too much
velocity	speed
accordingly; consequently	so
furthermore	then, also
nevertheless	but, however
adhere	stick
likewise	and, also

overloads of 50 per cent for occasional 10-second intervals without overheating."

Indecisiveness makes poor camouflage for a weak subject.

Verbosity: A phrase found frequently in service manuals is "care must be exercised." We don't exercise care (like walking a dog); we just are careful, or aren't. Saying "be careful" would be better.

Because verbosity means that too many words are used, this condition can be corrected by using fewer, more concise words to express the same thought. If no thought is presented, no words should be written.

Avoidance of the terse in favor of the verbose makes writing like quicksand—the reader may never get through it.

Showiness: Showy writing is interlarded with pretentious words such as terminate (end, stop), subsequent (next), investigate (study). The reader is disappointed when he breaks through this false front and finds that all that glitters is not chromium plated.

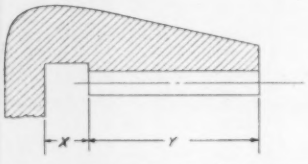
Showiness does not impart quality into writing any more than quality can be inspected into a casting. In the words of H. W. Fowler, author of *A Dictionary of Modern English Usage,* "Anyone who wishes to become a good writer should endeavor, before he allows himself to be tempted by the more showy qualities, to be direct, simple, brief, vigorous, and lucid."

The editing process is like redesigning a complex mechanism to make it lighter and simpler while still retaining the function of the mechanism. Careful editing, like good design, will ensure a superior, usable product.

Tips and Techniques

Internal Gear Relief

When designing internal gears, it is necessary to allow a clearance or relief, *X*, for the gear-shaper cutter so that it will not strike the workpiece. Be-

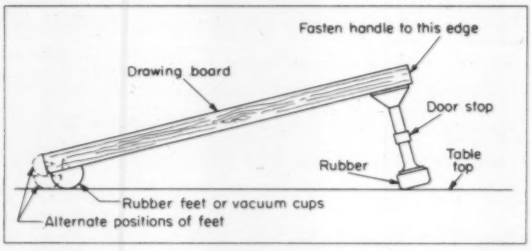


Stroke, *Y* (in.)	Spur Relief, *X* (in.)	Helical Relief, *X* (in.)
1	3/16	1/4
2	21/64	3/8
3	15/32	17/32
4	39/64	21/32
5	3/4	13/16

cause of cutter shape, more clearance is required for helical cutters than for straight spur-tooth cutters. Recommended clearances are given in the table.—GEORGE D. PHEILL, *Racine, Wis.*

Portable Drafting Board

A small drafting board can be readily adapted to make a portable unit which will not mar or damage furniture or table tops while the board is in use. Two screw-type metal door bumpers with rubber tips are fastened to the bottom of the board. Nail or screw two rubber bumpers to the lower edge as shown. The location of the bumpers and door stop "feet" will depend upon the size of the board and the angle desired. Vacuum cups may be used instead of rubber bumpers to secure the board to a table top. A leather strap



or handle on the upper edge of the board will facilitate carrying. — GENE J. KRYSKO, *design engineer, Research and Development, Dole Valve Co., Chicago.*

Speeding Dimensioning

When measuring from a center line, it is often necessary to mark off half a dimension, such as a radius where the diameter is known. The time taken by mental arithmetic and the possibility of errors can be eliminated by using a scale one-half the working scale and measuring to the full dimension. For instance, if the working scale is $\frac{3}{4}=1$, use the $\frac{3}{8}=1$ scale when dimensioning from the center line. Most draftsmen's scales are marked with pairs of scales on one edge, so that this is a convenient method to use.—SIDNEY REIBEL, *estimating engineer, Jervis B. Webb Co., Detroit.*

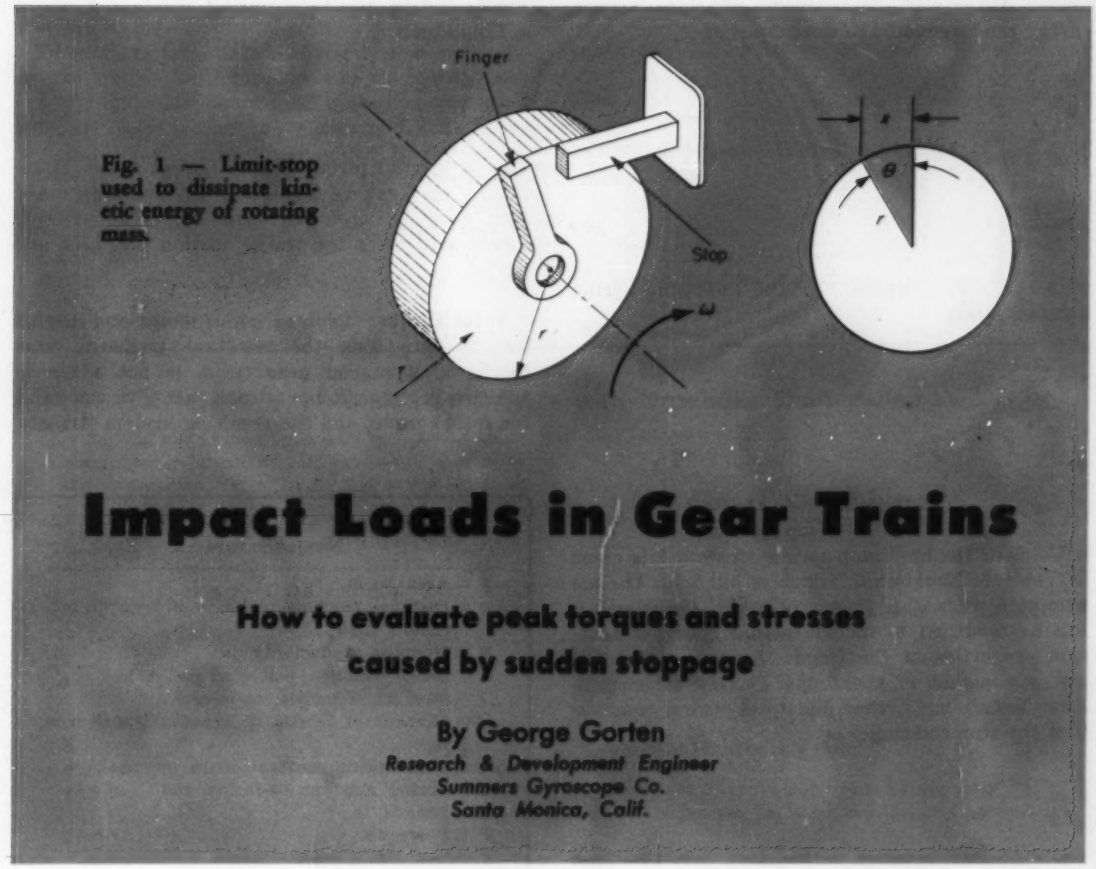


Fig. 1 — Limit-stop used to dissipate kinetic energy of rotating mass.

Impact Loads in Gear Trains

How to evaluate peak torques and stresses caused by sudden stoppage

By George Gorten
Research & Development Engineer
Summers Gyroscope Co.
Santa Monica, Calif.

STALL a power-transmitting gear train suddenly—for example, by introducing a mechanical limit-stop at its output end. Resulting stresses in both gear train and stop often reach extremely high values. Where rotational speeds and component inertias are low enough, usual practice is to design for motor stall torque alone; impact torque that results from the kinetic energy of rotation is ignored.

Kinetic energy, however, is a factor of special significance where speeds and inertias are high. Its effect is to add inertial impact torque to the stall-torque of the drive motor, giving a resultant that peaks at values much higher than stall torque alone.

Such peak torques are developed when a limit-stop positioned at the output end of the gear train, Fig. 1, is used to deliberately stall an actuator system. With such an arrangement, resilience of the gear train and mechanical stop must be considered before an exact stress evaluation can be be made. This article describes how combined torques and resulting stresses are calculated and compares results of both approximate and exact computation methods so as to permit prediction of the modifying action of system elasticity on developed stresses. Examples are presented for both methods.

Inertial Torque: A simple method giving the expression for maximum torque in a stalled actuator system equates work done on the elastic system members to the sum of work done by both motor-stall and inertial torques. Motor torque at stall is usually known from manufacturer's data. Inertial torque due to kinetic energy of rotation is calculated from the characteristics of the gear train.

A flywheel of inertia I, rotating at constant angular velocity ω, is brought to a halt by a mechanical limit-stop, Fig. 1. In this simple case, all kinetic energy is assumed to be absorbed by the stop, which has spring constant k; the finger is assumed to be completely rigid.

Kinetic energy of the spinning mass is

$$E = \frac{1}{2} I\omega^2 \qquad (1)$$

Because the limit-stop, acting as a spring, com-

presses distance $x = r\theta$, available rotational kinetic energy can be equated to work done, or

$$\frac{I\omega^2}{2} = \frac{T\theta}{2} \tag{2}$$

This is rewritten as

$$T = \frac{I\omega^2}{\theta} \tag{3}$$

Since $\theta = T/k$, where k is the limit-stop spring constant, then

$$T = \frac{I\omega^2}{\frac{T}{k}} \tag{4}$$

or

$$T = \omega\sqrt{Ik} \tag{5}$$

Value of the limit-stop spring-constant k is given in Table 1. Equation 5, which is valid for the assumption that the finger is rigid (nonelastic), can be modified to include actual energy-absorption properties of the finger. Assuming that the spring constant of the finger (acting as a cantilever beam) is k_1, then the total spring constant K of the stop and finger is

$$K = \frac{k\,k_1}{k + k_1} \tag{6}$$

Basis of this equation is the fact that combined elastic action of the stop and finger is equivalent to a series spring arrangement.

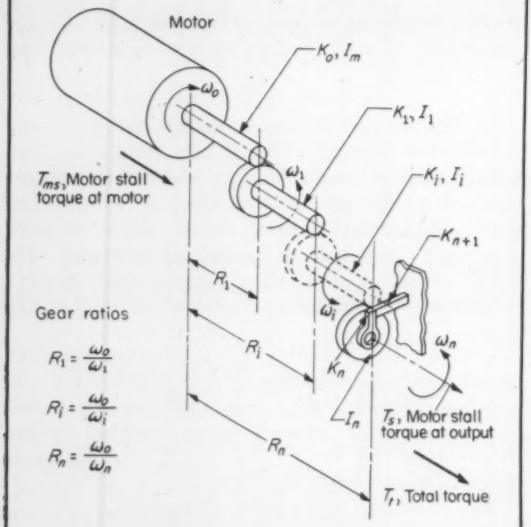


Fig. 2—Typical actuator gear train with limit-stop at output end.

Substituting the total spring constant K for k in Equation 5,

$$T = \omega\sqrt{\frac{I\,kk_1}{k + k_1}} = \omega\sqrt{IK} \tag{7}$$

This is inertial torque due to impact alone. Equations 5 or 7 can be applied to any spinning mass, such as a spring-driven gyro, where no external power acts after the initial motion has been imparted.

Total Torque: Combination of motor and inertial torques, providing the resultant transient total torque in a stalled gear train, is not a simple additive process. Computations that give the value for total torque, and the resulting system stresses,

Nomenclature

A = Area, sq in.
c = Distance from neutral axis of beam to outermost fiber, in.
E = Modulus of elasticity, psi
G = Shear modulus, psi or oz per sq in.
I = Moment of inertia, oz-in-sec^2
J = Moment of inertia of cross-sectional area, in.^{4}
K = Total spring constant, oz-in. per rad
k = Spring constant, oz-in. per rad
L = Length, in.
P = Force, lb
R = Gear ratio, dimensionless
r = Radius, in.
T = Torque, lb-in. or oz-in.
W = Work, in-lb or in-oz
x = Deflection, in.
τ = Stress, psi or oz per sq in.
ω = Angular velocity, rad per sec
θ = Angle of deflection, rad

Table 1—Spring-Constant Equations

Gear-System Component	Spring Constant (oz-in. per rad)
Limit-Stop: Acts as short compressive member; axial end deflection, x, corresponds to rotation θ of the finger.	$k = \frac{AEr^2}{L}$
Finger—End Fixed at Wheel Center: Acts as cantilever beam of length r; perpendicular deflection x_1 corresponds to angular rotation $\theta = x_1/r$.	$k_1 = \frac{3EJ}{r}$
Finger—Length L: Acts as cantilever beam with angular deflection occurring in length L; spring constant, however, is expressed in terms of finger rotation θ and radius r (Fig. 4).	$k_5 = \frac{3EJr^2}{L^3}$
Shaft: Acts as a fixed-ended cylindrical beam, length L and radius r, under torsional load (bending neglected).	$k_i = \frac{G\pi r^4}{2L}$

are outlined here for the representative actuator gear train, Fig. 2.

To evaluate total inertia of the system as "seen" by the output or limit-stop end of the system: (1) the individual inertias of each gear and shaft are first reflected to the motor end; (2) these reflected inertia values are added to the motor inertia; and (3) total inertia at the motor end—having been obtained by summation on "common ground"—is reflected back to the output end of the gear train.

By this procedure, total inertia of the components (Fig. 2) reflected to the motor end is

$$I_{tm} = I_m + \sum_{i=1}^{n} \frac{I_i}{R_i^2} = I_m + I_g \tag{8}$$

In this expression, equivalent inertia of the gear train is

$$I_g = \sum_{i=1}^{n} \frac{I_i}{R_i^2} \tag{9}$$

Reflecting the total equivalent inertia at the motor

Example 1—Limit-Stop Stresses with Nonelastic Shaft Action

For the motor gear train with component characteristics given in Fig. 4, equivalent inertia of the gear train, reflected to the motor shaft is

$$I_g = \Sigma_{i=1}^{5} I_i/R_i^2$$

$$= 10^{-6}\left(\frac{185}{8^2} + \frac{514}{32^2} + \frac{354}{120^2} + \frac{1004}{460^2} + \frac{1180}{1610^2}\right)$$

$$= 3.41 \times 10^{-6} \text{ oz-in-sec}^2 \tag{1a}$$

Equivalent inertia reflected to the limit-stop end is

$$I_e = (I_m + I_g)R_n^2$$

$$= (82.9 + 3.41)(10^{-6})(2.56 \times 10^6)$$

$$= 221 \times 10^{-6} \text{ oz-in-sec}^2 \tag{2a}$$

Torque due to inertia, as given by Equation 7, is

$$T = \omega\sqrt{I_e K} \tag{3a}$$

where K is, as yet, unknown.

Since energy absorption in this example is assumed to occur in only the limit-stop and finger (inelastic shafts), the overall spring constant is

$$K = \frac{k_5 k_6}{k_5 + k_6} \tag{4a}$$

Since, from Fig. 4, $d = \frac{1}{4}$-in., $r = 0.969$-in., and $E = 30{,}000{,}000$ psi, then employing consistent units,

$$k_6 = \frac{AEr^2}{L_1}$$

$$= \frac{0.049(4.8 \times 10^8)(0.945)}{0.344}$$

$$= 64.5 \times 10^6 \text{ oz-in. per rad} \tag{5a}$$

Value for k_5 is calculated from the expression given in Table 1 as

$$k_5 = \frac{3EJr^2}{L_2^3}$$

$$= \frac{3(4.8 \times 10^8)(6.36 \times 10^{-4})(0.969^2)}{0.719^3}$$

$$= 2.35 \times 10^6 \text{ oz-in. per rad} \tag{6a}$$

Substituting k_5 and k_6 into Equation 4a, the overall spring constant is

$$K = \frac{(64.5 \times 10^6)(2.35 \times 10^6)}{(64.5 + 2.35)(10^6)}$$

$$= 2.23 \times 10^6 \text{ oz-in. per rad} \tag{7a}$$

Since $\omega = 3$ rpm $= \pi/10$ rad per sec, and with K from Equation 7a, Equation 3a gives

$$T = \frac{\pi}{10}\sqrt{221\ (2.23)\ (10^6)}$$

$$= 6970 \text{ oz-in.}$$

$$= 436 \text{ lb-in.} \tag{8a}$$

Assuming 70 per cent gear efficiency, stall torque at the output is

$$T_s = \frac{2.4(1610)(0.7)}{16}$$

$$= 169 \text{ lb-in.} \tag{9a}$$

Total torque in the gear system at stall is then given by Equation 14 as

$$T_t = \frac{1}{2}\left(169 + \sqrt{169^2 + 4(436^2)}\right)$$

$$= 529 \text{ lb-in.} \tag{10a}$$

Stress in the stop is

$$\tau_s = \frac{T}{rA_s} = \frac{529}{0.969(0.049)}$$

$$= 11{,}150 \text{ psi} \tag{11a}$$

Stress in the finger is

$$\tau_f = \frac{Tc}{J} = \frac{(529)(0.156)}{6.36 \times 10^{-4}}$$

$$= 129{,}400 \text{ psi} \tag{12a}$$

end, Equation 8, to the limit-stop end,

$$I_e = \left(I_m + \sum_{i=1}^{n} \frac{I_i}{R_i^2} \right) R_n^2 = I_{tm} R_n^2$$

$$= \left(I_m + \frac{I_1}{R_1^2} + \frac{I_i}{R_i^2} + \ldots + \frac{I_n}{R_n^2} \right) R_n^2 \qquad (10)$$

The expression relating total torque in the gear train at stall is obtained from an energy balance. Equating work done *on* the spring stop and all other resilient gear-train members to work done *by* motor stall-torque plus work due to inertial torque, $W_e = W_s + W_{ke}$, or

$$\frac{T_t \theta}{2} = \frac{T_s \theta}{2} + \frac{I_e \omega^2}{2} \qquad (11)$$

Solving for T_t,

$$T_t = T_s + \frac{I_e \omega^2}{\theta} \qquad (12)$$

Since K is the total spring constant of all resilient members, $T_t = K\theta$, and from Equation 12,

$$T_t = T_s + \frac{I_e \omega^2}{\frac{T_t}{K}} = T_s + \frac{I_e \omega^2 K}{T_t} \qquad (13)$$

Equation 13 is then solved for total torque, giving

$$T_t = \frac{1}{2} \left(T_s + \sqrt{T_s^2 + 4 I_e \omega^2 K} \right) \qquad (14)$$

Substituting the right side of Equation 7 into Equation 14, total torque can also be expressed as

$$T_t = \frac{1}{2} \left(T_s + \sqrt{T_s^2 + 4 T_I^2} \right) \qquad (15)$$

Equation 15 can be used to find total torque when inertial torque is known; or, as an alternate method, Equation 14 can be used with known inertia and spring constant to give the same result in single-step solution.

Equation 14 reduces to Equation 7 when $T_s = 0$, and therefore applies where no external power source supplies torque to the gear system at the time of stall.

Derivation of the expression for total torque

Table 2—Summary of Calculations

	K (oz-in./rad)	T_I (lb-in.)	T_t (lb-in.)	τ_s (psi)	τ_f (psi)
Nonelastic shafts (*Example* 1)	2.23×10^6	436	529	22,800	129,400
Elastic shafts (*Example* 2)	2.09×10^6	422	515	10,860	126,600

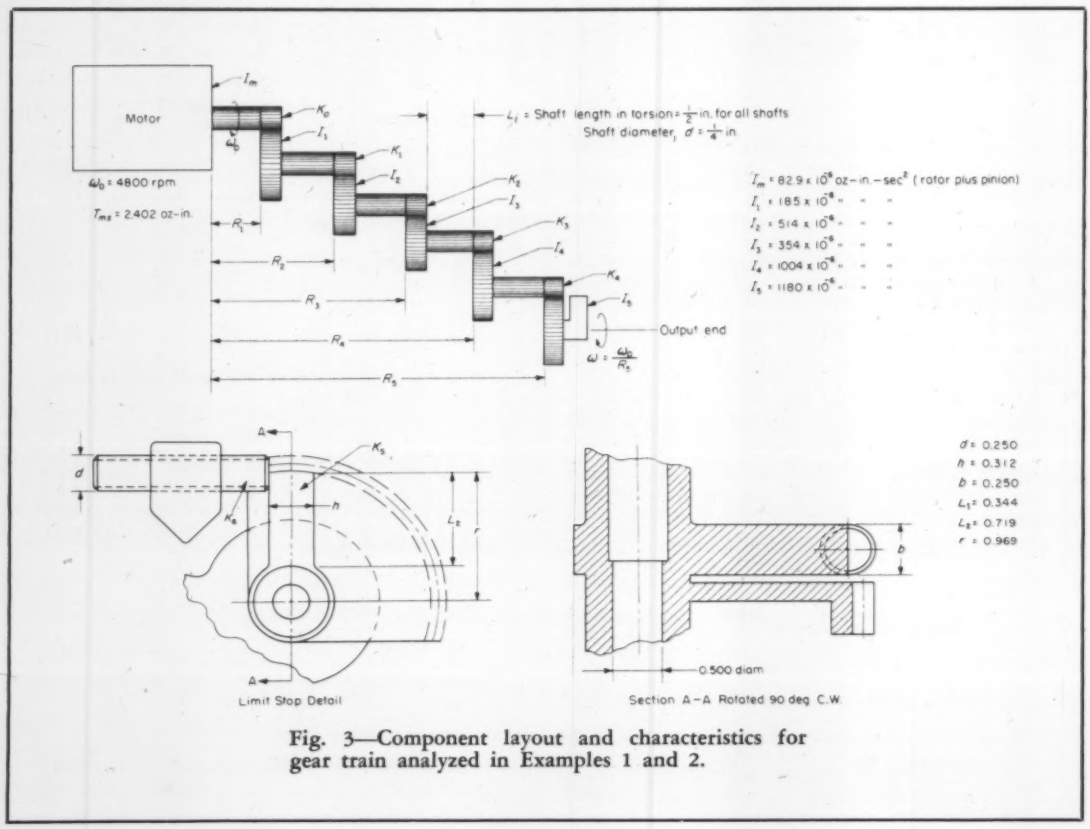


Fig. 3—Component layout and characteristics for gear train analyzed in Examples 1 and 2.

is based on the assumption that the motor stall-torque increases linearly with time. This fact remains to be experimentally confirmed by actual test data. The total torque expression, Equation 15, however, serves as a close approximation to actual conditions and provides a practical estimate in preliminary design.

Limit-Stop Assembly Stresses: With the value of total maximum torque known for the system, conventional methods give stresses in both the limit-stop and finger. In the stop, which deflects as a short compression member,

$$\tau_{max} = \frac{P}{A_s} = \frac{T}{rA_s} \tag{16}$$

In the finger, which deflects as a cantilever beam,

$$\tau_{max} = \frac{Tc}{J_f} \tag{17}$$

These stresses can be compared to the allowable stresses in the materials so as to guarantee sufficient strength in the stop assembly.

Effects of System Elasticity: Intuitively, it may be foreseen that elasticity of system components—including all shafts and gears—will reduce the magnitude of shock stresses caused by a sudden stall. In Examples 1 and 2, computations for a gear train, Fig. 3, are carried out with the assumptions: (1) that all energy absorption occurs at the limit stop (other components of the system are rigid); and (2) limit-stop and shafts are elastic (bending of shafts and gear-teeth deflection neglected).

Comparison of results of these computations is given in Table 2. It is noted that elasticity of the shafts does, in fact, reduce total impact torque and the resulting stresses. Practical result of this finding is to allow rough computation of stresses with all shafts assumed to be rigid and energy absorption assumed to occur only in the limit-stop assembly. Identical reasoning shows that exclusion of both elasticity of the shafts in bending and elasticity of the gear teeth provides a conservative short cut to the stress calculations.

Example 2—Limit-Stop Stresses with Elastic Shaft Action

From Table 1, the general expression for the spring constant of a shaft in torsion is

$$k_i = \frac{G\pi r_i^4}{2L_i} \tag{1b}$$

Since $L_i = \frac{1}{2}$-in., $r_i = \frac{1}{8}$-in. and shear modulus $G_i = 1.92 \times 10^8$ oz per sq in.,

$$k_i = \frac{(1.92 \times 10^8)(\pi)}{256(2)(0.5)}$$

$$= 2.36 \times 10^6 \text{ oz-in. per rad}$$

$$= K_4 = K_3 = K_2 = K_1 = K_0 \tag{2b}$$

Values of K_5 and K_6 are given in Example 1.

Spring constants K_1 through K_4 (shafts 1 through 4) must be multiplied by the square of the respective gear ratios of the shafts to the output when individual spring constants are used in an expression for overall K.

$$\frac{1}{K} = \sum_{i=0}^{n+1} \frac{1}{K_i(R_{i-n})^2}$$

or

$$\frac{1}{K} = \frac{1}{K^6} + \frac{1}{K^5} + \frac{1}{K_4\left(\frac{R_5}{R_4}\right)^2} + \frac{1}{K_3\left(\frac{R_5}{R_3}\right)^2} + \frac{1}{K_2\left(\frac{R_5}{R_2}\right)^2} + \frac{1}{K_1\left(\frac{R_5}{R_1}\right)^2} + \frac{1}{K_0(R_5)^2} \tag{3b}$$

In this case, K_5 and K_6 remain unaltered since they are multiplied by the ratio $(R_5/R_5)^2 = 1$.

Substituting values of K_1 to K_6 in Equation 3b,

$$K = 2.09 \times 10^6 \text{ oz-in. per rad} \tag{4b}$$

Comparison of this value with the overall $K = 2.23 \times 10^6$ given by Equation 7a, Example 1, shows that consideration of additional k_i always reduces the overall spring constant. Consequently, when shaft elasticity is neglected, stress computations are conservative.

In this example, torque due to inertia is

$$T_I = \frac{\pi}{10}\sqrt{221\,(2.09 \times 10^6)}$$

$$= 6750 \text{ oz-in.}$$

$$= 422 \text{ in.-lb} \tag{5b}$$

Stall torque $T_s = 169$ lb-in. as in Example 1. Therefore, total torque where shaft elasticity is a factor is

$$T_t = \frac{1}{2}(169 + \sqrt{169^2 + 4(422)^2}$$

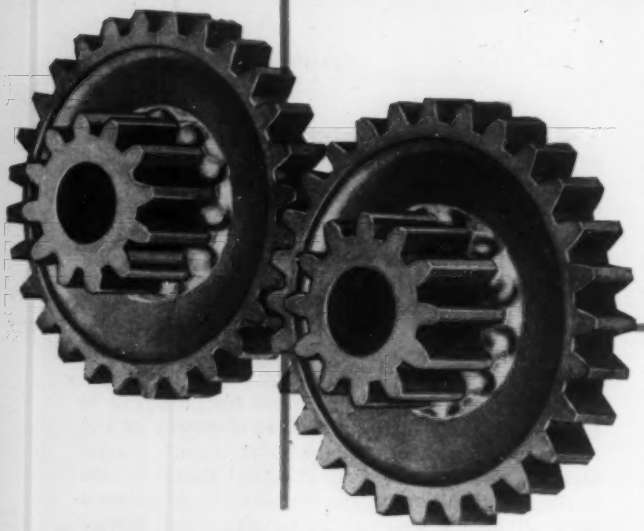
$$= 515 \text{ in.-lb} \tag{6b}$$

Stress in the shop is now

$$\tau_s = 10{,}860 \text{ psi} \tag{7b}$$

Stress in the finger is

$$\tau_f = 126{,}600 \text{ psi} \tag{8b}$$



SHELL-MOLD CASTINGS . . .

Shell-mold castings offer excellent dimensional accuracy and surface finish. Parts designed for the process may be quite intricate and require very little draft. The process offers advantages in eliminating or reducing machining and finishing operations. Based upon a chapter of the book, *Illustrated Casting Methods*, soon to be published by Howard Foundry Co., Chicago, this article describes shell molding and casting design.

SHELL-MOLD casting is a relatively new process in the United States, dating back to about 1949. Although much information has been published about the process, a large part has been based on laboratory results. Tolerances that the process is supposedly capable of supplying are frequently impractical on a production basis. When shell molding is expected to produce extremely close tolerances, such as ±0.003 to 0.008-in. per in., the results have invariably been discouraging. Shell molding however, does have important production and cost advantages. It merits consideration in many areas where it has not yet been applied.

An example is a 27-tooth ductile-iron bevel gear, Fig. 1. The manufacturer obtained three competitive quotations from shell-mold foundries. One quotation was based upon casting the gear blanks to a tolerance of ±0.020-in. with the teeth to be machined by the manufacturer. The other quotations figured the gears with teeth cast to ±0.020-in. Even with the teeth cast in, these tolerances did not satisfy the manufacturer's requirements. The gears were already being made; the objective was to eliminate most of the machining operations.

Foundry engineers were then advised that the gears were for a hand-operated lifting mechanism. They were not subject to extensive loads and overall requirements

Fig. 1—Bevel gears are used with teeth as-cast, without machining. Gears are 3½ in. diam; material is ductile iron.

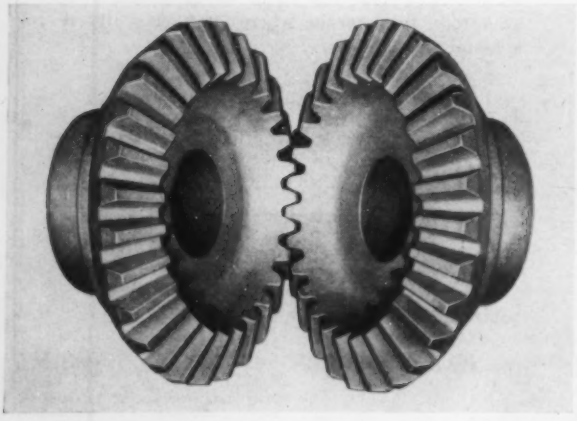
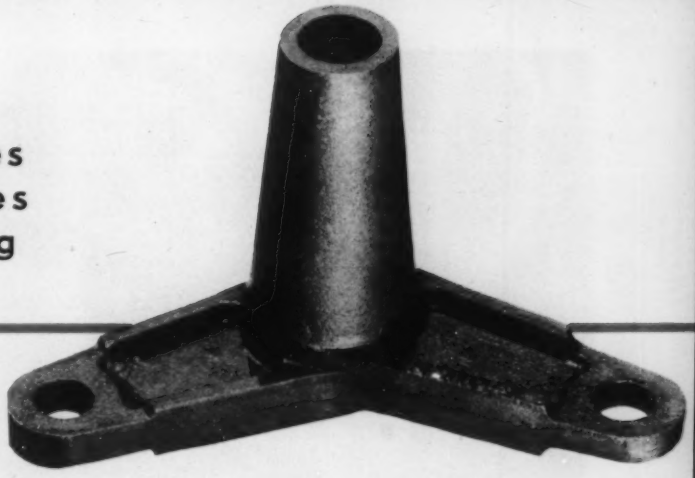


Fig. 2—Typical shell molded steel casting of 0.30 carbon steel. Rough surface is characteristic only of low-carbon steel alloys.

FOR complex shapes
smooth surfaces
intricate coring



were not critical. The only critical area was the gear teeth. If cast to plus or minus 0.020-in. maximum accumulative, as checked by rolling against a master, the manufacturer could switch his gear production to shell.

Production shell - mold gears are being supplied to this tolerance. They mesh very well in the as-cast condition, eliminating 75 per cent of the machining.

Complex shapes which have intricate coring can be cast in shell molds. Similarly, when shell-mold cores are used in green-sand casting, it is usually due to the closer tolerances, better finishes and more complex shapes possible with the shell core. There are limitations in shell coring, of course, but coring limitations are found in every casting process.

Shell-mold castings can often improve the outward appearance of an assembly without finish machining. Finish attained will vary with design of the casting and the alloy selected. Low-carbon steel alloys, with carbon under 0.30 and cross sections under ¼-in., seldom have good as-cast finishes. Apparently, the carbon reacts with certain elements in the resin-sand shell mixture, causing rough surfaces, Fig. 2. Aside from this skin condition, shell mold produces acceptable castings in the low-carbon steel alloys.

Other ferrous alloys, including most other types of steel alloys, are molded with finishes ranging from

Design Recommendations

Tolerances
Steel and nonferrous alloys: ±0.020-in. per in.
Iron: ±0.015-in. per in.
Eccentricity, any material: ±0.020-in.

Angular tolerances
±0 deg 45 min.

Draft
0.002-in. per in. min

Concentricity
0.002-in. per in.

Hole diameter and location
Steel and nonferrous alloys: ±0.020-in. per in.
Iron: ±0.015-in. per in.
If under 5/16-in. diam, omit when tolerance is under ±0.010-in.
If over 5/16-in. diam, add machining stock

Hole depth
Through: 5/16-in. diam or over, 2 times diam
Blind: 5/16 to ¾-in. diam, 1 diameter
¾ to 1¼ in. diam, 2 times diam
1¼ in. diam and over, 3 times diam

Chamfers
Producible if over 0.010-in. wide

Sharp corners
Producible in gray iron and ductile iron
Avoid in steel and nonferrous alloys

Interior corners
Generous fillet radius recommended

Wall thickness
Gray iron and ductile iron: ⅛-in. min
Steel, aluminum and magnesium: 3/16-in. min

Flatness and straightness
Steel and nonferrous alloys: ±0.020-in. per in.
Iron: ±0.015-in. per in.

Machining stock
1/16-in. preferred

Pattern mismatch
Normally 0.010-in. max, except where multiple patterns are involved; these may require realignment

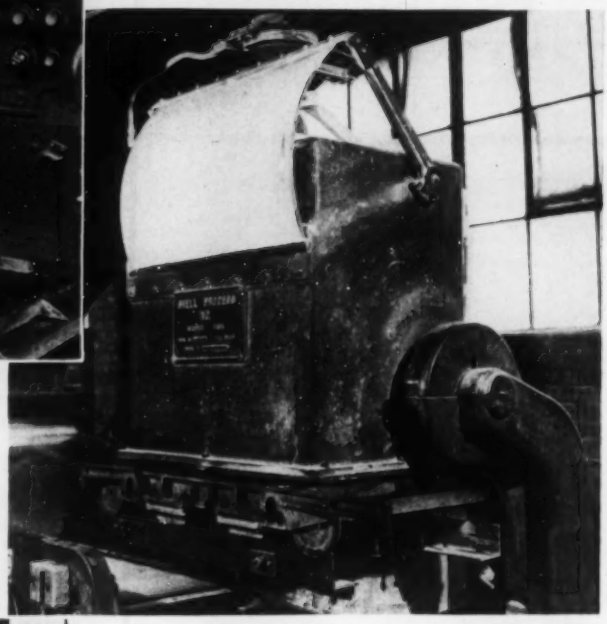
Surface finish as cast
Ferrous alloys: 150 to 250 rms
Nonferrous alloys: 125 to 200 rms
Ductile iron: 100 to 150 rms
Low-carbon steels: poor

Weight limitation
Normally 30 lb for ferrous, 25 lb for nonferrous

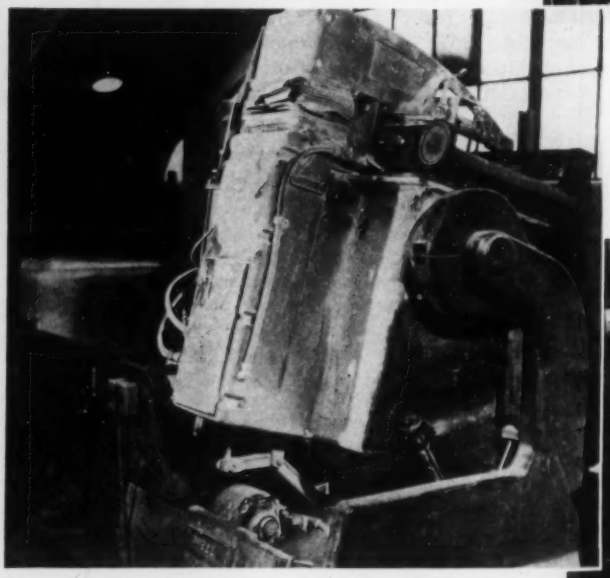
Size limitation for automatic equipment
20 by 30 in. considered max
8 in. height from parting line is max

Applicable materials
Steel alloys
Nickel-iron alloys (ductile iron)
Gray iron
Aluminum and magnesium
Brass and bronze

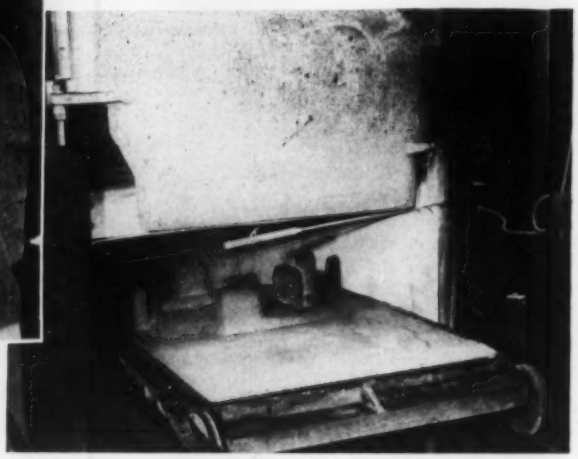
Release agent is sprayed on matchplate pattern prior to investing resin-sand mixture. Pattern is then preheated to 450 to 550 F.



Investing of resin-sand mixture is done automatically. Pattern carriage moves under mixture chamber and is clamped to it. Sheet-steel louver rises from chamber allowing resin-sand to drop on heated pattern where it adheres and melts. Investment cycle time is from 15 to 30 seconds, depending on shell size and thickness.



Rollover of mixture chamber drops excess sand back inside chamber, where it is trapped by louver. Chamber returns to upright position and iron pattern carriage is unclamped, revealing soft resin-sand shell, about ¼-in. thick.

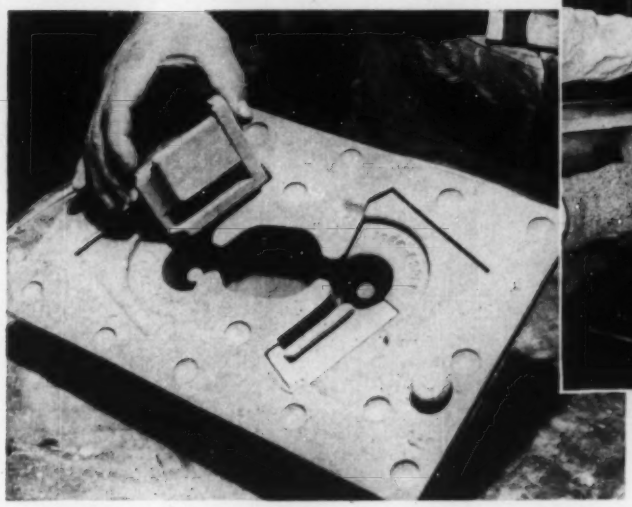


Uncured shell on carriage rolls into curing oven. Bake is 20 to 40 seconds at a temperature between 900 and 1400 F. After baking, shell and pattern are ejected automatically from oven.

150 to 250 rms. However, for finish alone, no ferrous alloy seems to equal ductile iron. Parts cast from this material consistently average between 100 and 150 rms. Nonferrous alloys have finishes averaging from 125 to 200 rms.

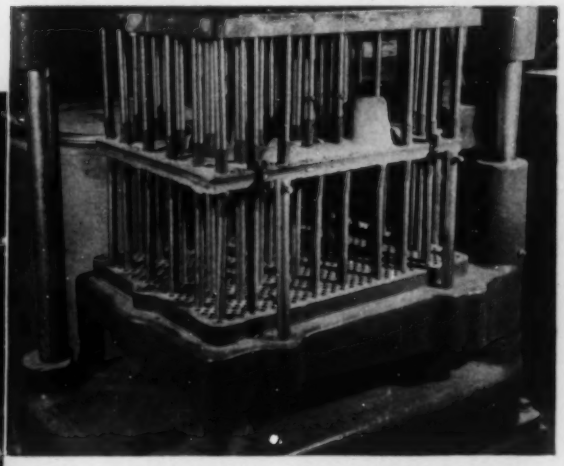
Metal-cooling rate of shell molding is readily controllable, eliminating difficut shrinkage problems. Varying cross sections, usually difficult to cast, are readily cast in shell mold. Grain fineness of shell mold castings is excellent. Photomicrograph inspections show that shell castings have what might be termed "cooling-rate inversion." Unlike sand mold, permanent mold and die castings, which have hard skins and "soft" interiors, shell-mold castings have "soft" skins and hard, or dense, interiors. As a result, shell-mold castings display superior machining characteristics.

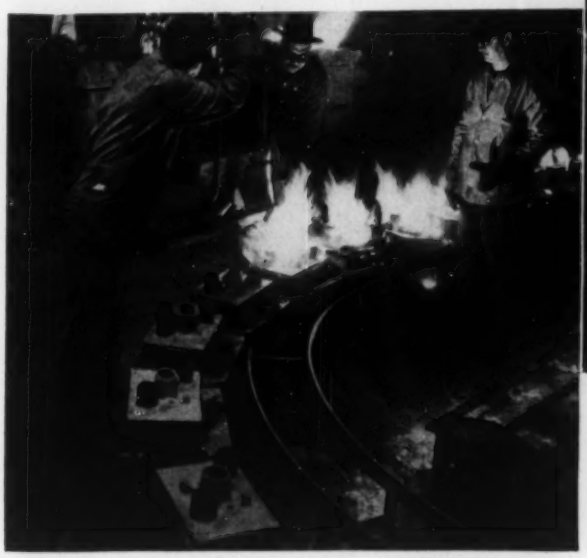
Hard, cured shell is easily stripped from pattern by hydraulically operated platen which pushes against ejector pins located in pattern plate.



Shell cores, molded of same mixture as mold halves, are made in iron core patterns. Cured shell cores are ready for mold assembly upon removal from oven and are inserted prior to bonding of shell halves.

Bonding of shell halves is completed in 30 to 60 seconds. Low-cure, phenol-formaldehyde synthetic adhesive is applied by machine to various contact points on shells. Halves are joined and set under pressure in hydraulic press.





Completed shell molds are conveyed to pour-off area and poured in horizontal position. Molds are held together only by adhesive, although experimental molds may use clamps. No shot or sand backup is used to reinforce molds.

For shell molding, 1/16-in. machining stock is considered normal and is desired in preference to a greater allowance. One firm, with a captive foundry and machine shop, conducted tests proving that tool-life is directly proportional to stock removal. Tests also proved that tool-life ratio was as high as 12:1 for shell-mold castings to green-sand castings. For testing purposes, the same amount of stock was removed from both types of castings.

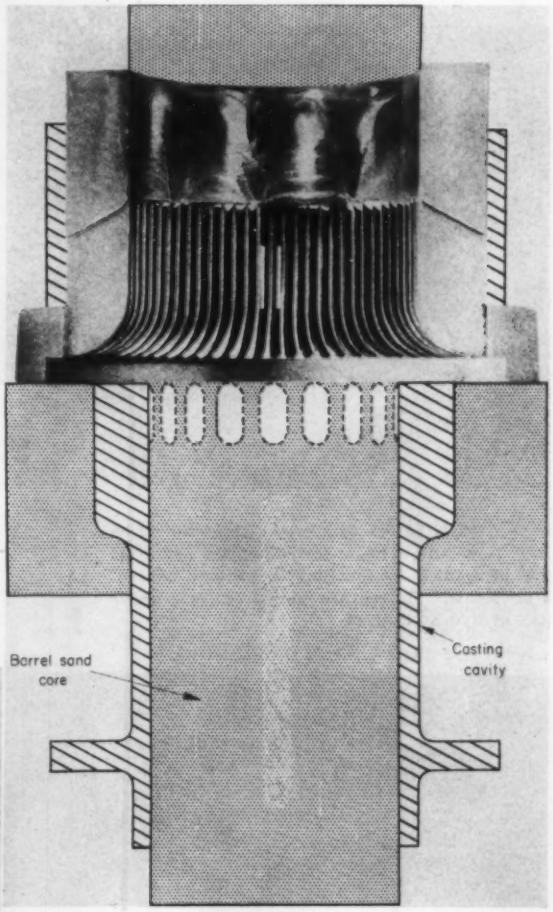
It is not unusual to see a part that could be more economically produced by the shell-mold process channeled into green-sand or all-core mold. This often results when the cost of shell mold patterns is prohibitive due to their accuracy requirements. Shell-mold match-plate patterns are machined of iron to meet the exacting requirements

necessary for production use. Aluminum matchplates tend to warp and grow under the constant temperatures that patterns are subjected to.

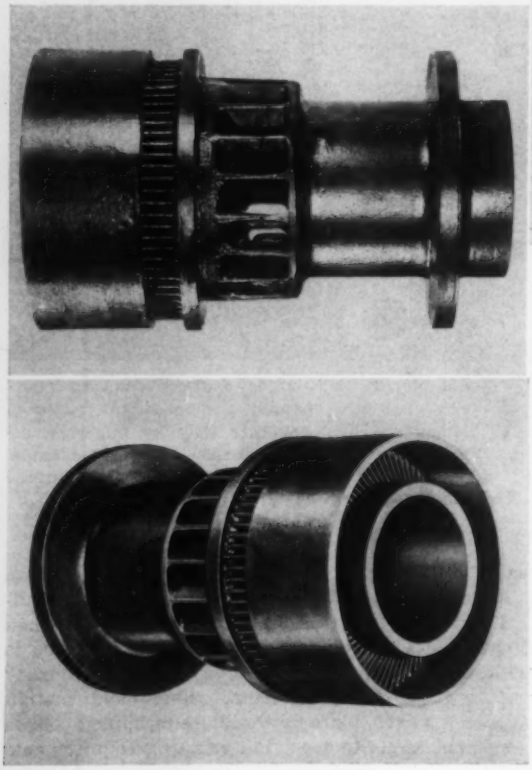
Aluminum matchplates, often used in green-sand molding, have been used for making shell molds. The shell castings have better dimensional consistency, finer finishes and sharper detail. Of course, no attempt is made to hold close tolerances with the aluminum matchplate. Usually the purpose is simply to gain the higher casting yield that is possible by the shell-mold process.

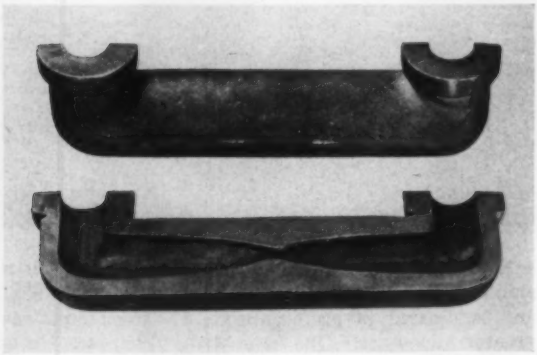
Standard tolerances are considered as ±0.020-in. per in. for nonferrous and steel alloys. For iron they are usually ±0.015-in. per in. Sometimes, when initial tooling cost is offset by machining savings, tolerances may be as close as ±0.010-in. per in. Eccentricity tolerances are figured at ±0.020-in.

The standard rule for draw is twice the diameter of draw-depth of blind holes. However, this is not constant; many exceptions are being made under production conditions. Minimum wall thickness is usually ⅛-in. for gray iron and ductile iron, and 3/16-in. for steel, aluminum and magnesium alloys.



Shell cores are frequently used to mold intricate internal shapes in sand castings. Ductile-iron cylinder has 72 cooling fins ⅛-in. thick, too delicate to mold successfully with a sand core. Weight is 21 lb (machined); length is 12½ in.; OD is 7 in.

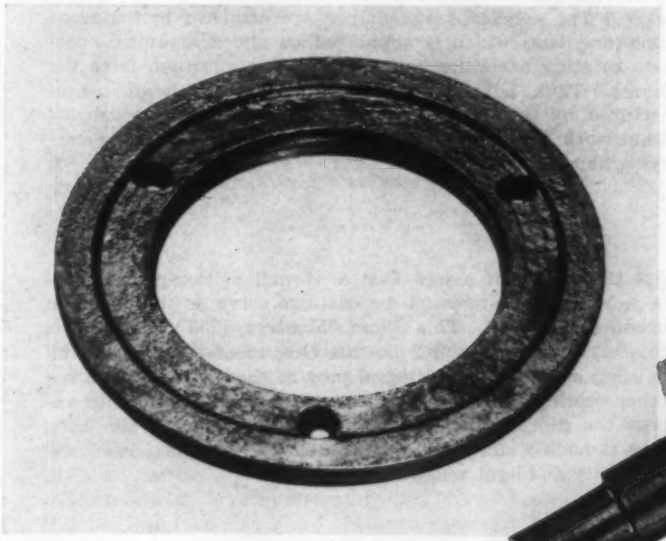




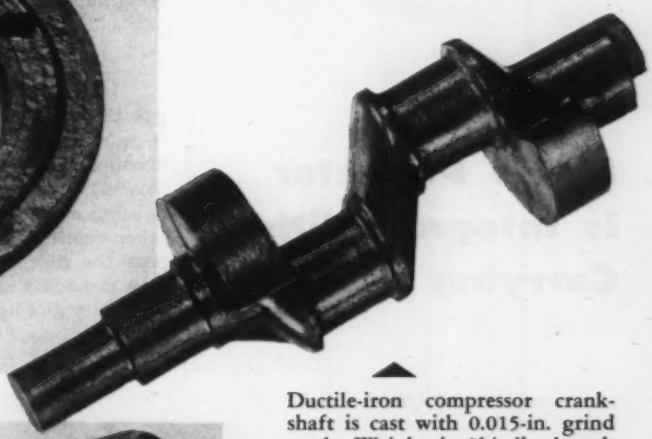
Inlet nozzle, cast from AMS 5385-B stainless steel, is sectioned to reveal cored passageway with ¼-in. diam orifice. Weight is 2½ lb; length is 7 in.

Capacity of mold-investing equipment determines maximum size of parts which may be cast. At Howard Foundry, typical of the industry, maximum automatic plate size is 20 by 30 in. Plate size may be sectioned into any convenient smaller mold size, as 15 by 20 in., 10 by 30 in., 10 by 15 in., 7½ by 20 in., or 6.6 by 7½ in. Maximum pattern height, or maximum height from parting line, is 8 in. If the parting line is in the center of a part, the maximum total height is 16 in. Manual equipment has plate size of 16 by 20 in., with useful area of 14 by 18 in. Maximum pattern height is 5 in.

Feather edges can be cast in gray iron and ductile iron, usually with excellent results. In steel and nonferrous alloys, feather edges are unsatisfactory and are not recommended. Feather edges are subject to the chill condition and usually are brittle. Heat treatment will not always relieve this condition. Coarse helical threads may be readily cast by the shell-mold process. Fine threads, of course, must be machined.



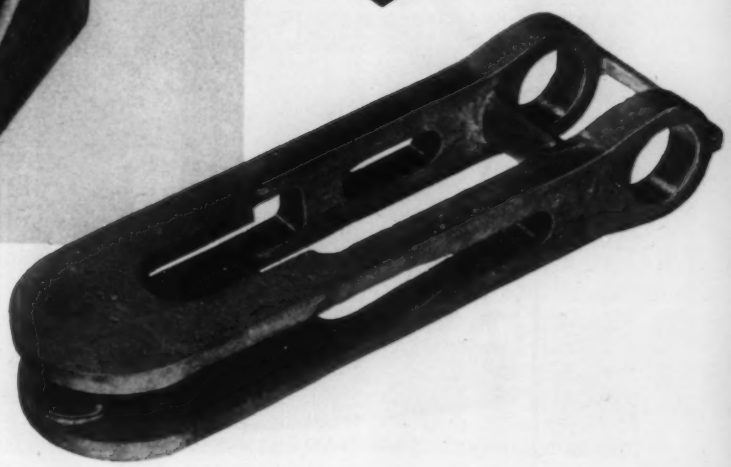
Seal facing ring is cast of Ni-Hard. Ring is supplied with as-cast hardness of Rockwell C 60. Weight is 6 oz; OD is 3⅝ in.; thickness is ¼ in.



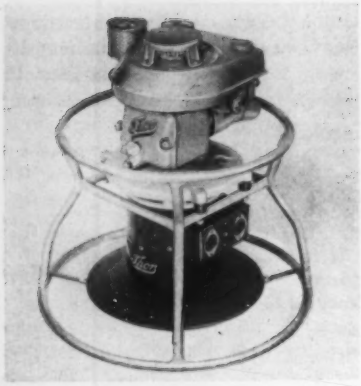
Ductile-iron compressor crankshaft is cast with 0.015-in. grind stock. Weight is 3½ lb; length is 8½ in.

Aircraft bracket of AZ91 magnesium requires test bars, chemical and physical reports, and X-ray inspection of castings. Weight is 11 oz; length is 3½ in.

Yoke is a complex casting of SAE 8620 steel, requiring good as-cast finish. Weight is 2¼ lb; length is 9 in.; width is 2½ in.



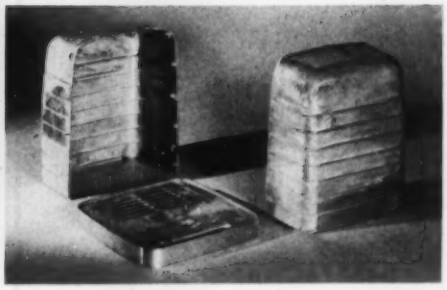
Vertical Engine-Generator Set Floats in Tubular Frame



VERTICAL shaft design used in a new portable engine-generator set permits a simple method of shock mounting. With the shaft operating in a vertical position, the entire weight of the generator is supported by a tubular framework. The generator and engine are attached to the same mounting base which is supported on shock mounts to isolate rotating armature action and engine vibration from the frame. Thus, both engine and generator, which are manufactured by the Thor Power Tool Co., float in the tubular framework that also serves as a protective guard and carrying handle.

Movie Projector Is Integral With Carrying Case

IN the design of a new Bell & Howell motion-picture projector, three aluminum die castings serve as the complete housing and base. This 8-mm "Monterey 253" projector is securely mounted on the die-cast base member. One of the housing castings is an integral part of the projector, and the other casting snaps off by means of a release button to expose the film-handling mechanism. The aluminum die castings provide a unit that has a quality appearance, excellent durability and light weight.



Significance of material properties in

Design for Fatigue Loading

Part 4 — Failure Theories Working-Stress Relations

By Joseph Marin
Professor and Head, Dept. of Engineering Mechanics
Pennsylvania State University, University Park, Pa.

FLUCTUATING loads acting on structural and machine parts often produce fatigue stresses in more than one direction. For example, under the action of fluctuating bending and torsional loads, a rotating shaft is subjected to biaxial fatigue stresses.

Relatively little experimental data have been obtained on the combined fatigue strength of metals (References 52 to 57 and 63 to 69). The lack of information is explained by the difficulties inherent in the design and operation of combined fatigue-stress testing machines. As in the case of static combined stresses, various theories have been proposed to express the fatigue strength for combined stresses in terms of the fatigue strength for uniaxial stress. A review of the commonly used theories, with some modifications, is presented in this article. For all theories discussed, it is assumed that the directions of the principal stresses do not vary during loading. It is also assumed that maximum and minimum values of the principal stresses occur at the same instant of time. If this synchronous condition does not exist in an application, the assumption made will be on the side of safety.

Failure Theories

Engineering-type theories of failure for fatigue are based on physical concepts of failure similar to those used for static combined stresses. In other words, failure under combined fatigue stresses is assumed when either limiting stress, strain, or energy reaches the corresponding value at failure for a uniaxial fluctuating stress. Such theories are reviewed in References 1, 14, 15, 16, 23, 33 and 51.

[16]References are tabulated at end of article.

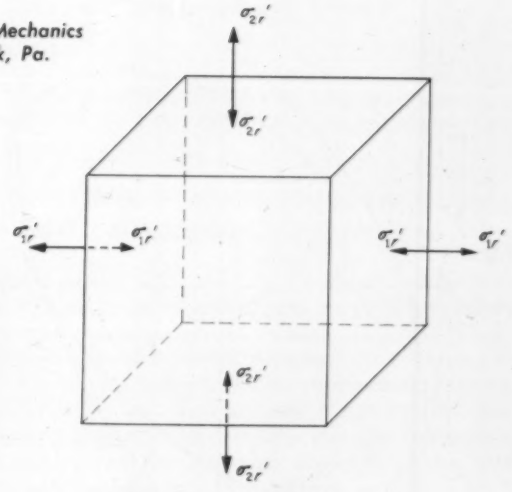


Fig. 25 — Completely reversed biaxial stresses.

Completely Reversed Stresses: For ductile materials, the main theories that have been proposed are the *maximum-shear theory* and the *distortion-energy theory*. The distortion-energy is the one usually specified in design codes.[16, 17, 21]

DISTORTION-ENERGY THEORY: For isotropic materials and completely reversed combined stresses, Fig. 25, fatigue failure by the distortion-energy theory can be expressed by a modification of Equation 25 (Part 2). Replacing σ_t by σ_e, and σ_1, σ_2, and σ_3 by σ_{1r}', σ_{2r}' and σ_{3r}',

$$(\sigma_{1r}' - \sigma_{2r}')^2 + (\sigma_{2r}' - \sigma_{3r}')^2 + (\sigma_{3r}' - \sigma_{1r}')^2 = 2\,\sigma_e^2 \qquad (62)$$

where σ_e is the fatigue strength for completely reversed uniaxial stress, and σ_{1r}', σ_{2r}' and σ_{3r}' are the fluctuating principal stress components.

For brittle materials and completely reversed stresses, a maximum-stress theory was proposed

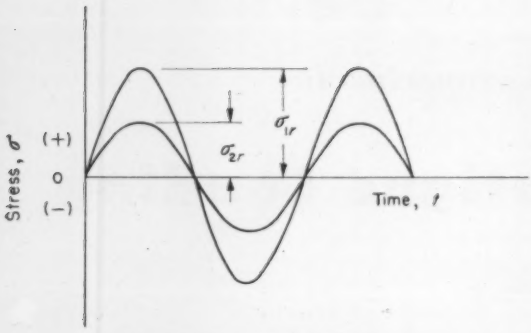


Fig. 26 — Variation of biaxial stresses with time.

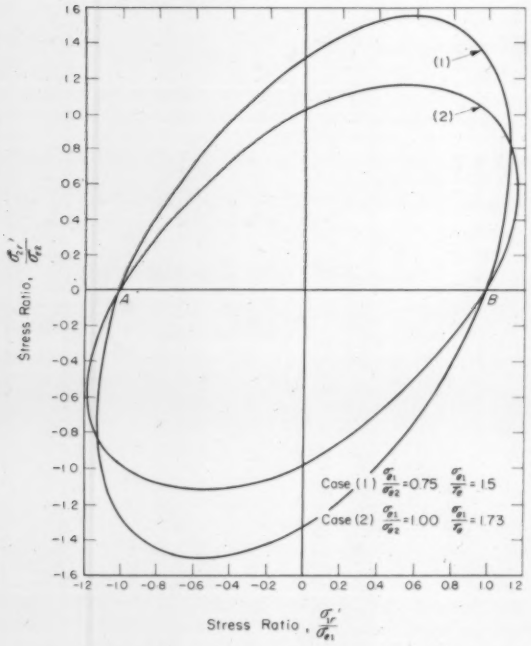


Fig. 27—Fatigue-strength theory for combined stresses and nonisotropic materials.

by Soderberg.[61] This theory is based on the straight-line uniaxial failure relation as given by Equation 45 (Part 2).

A considerable amount of test data indicates that Equation 62 gives a good approximation to test data on ductile materials and that, in general, the theory predicts strengths that are on the safe side.

Various investigators, however, have proposed new failure relations that give a more accurate representation of certain test data than is provided by Equation 62 (References 51, 52, 59, 60). These relations consider stress conditions represented by combined bending and torsion. All possible combinations of torsion and bending loads provide only limited principal stress ratio, ranging from 0 to −1.0. Any appraisal on the accuracy of these various relations should consider their validity for stress combinations other than combined torsion and bending. Since most combined fatigue-strength data have been obtained for combined bending and torsion, it is not surprising that some of the proposed theories are adequate only for interpreting such test results.

MODIFIED DISTORTION-ENERGY THEORY: A modification of the distortion-energy theory which provides a more accurate agreement with combined torsion and bending test data has been proposed.[58] This theory also provides for anisotropy of the material. Its basis is similar to that of the static-strength theory for combined stresses and anisotropic materials as expressed by Equation 28 (Part 2). The *anisotropic theory for fatigue* can be expressed by replacing the uniaxial static strengths in Equation 28 by the fatigue values and by replacing σ_1, σ_2, and σ_3 by σ_{1r}', σ_{2r}', and σ_{3r}', respectively. Then failure is expressed by

$$(\sigma_{1r}')^2 + \left[1 + \left(\frac{\sigma_{e1}}{\sigma_{e2}}\right)^2 - \left(\frac{\sigma_{e1}}{\tau_e}\right)^2\right] \sigma_{1r}' \sigma_{2r}' + \left(\frac{\sigma_{e1}}{\sigma_{e2}}\right)^2 (\sigma_{2r}')^2 = \sigma_{e1}^2 \qquad (63)$$

where σ_{e1} = uniaxial fatigue strength for complete stress reversal in the σ_1 direction, σ_{e2} = uniaxial fatigue strength for complete stress reversal in the σ_2 direction, τ_e = fatigue strength for complete stress reversal in pure torsion, and σ_{1r}' and σ_{2r}' = completely reversed biaxial stresses in the σ_1 and σ_2 directions as shown in Fig. 25.

In the expression for fatigue failure, Equation 63, it is assumed that both maximum and minimum stress components occur at the same instant of time, as shown in Fig. 26. Variation in the fatigue strength σ_{1r}' for various values of stress σ_{2r}' can be plotted by first rewriting Equation 63 as

$$\left(\frac{\sigma_{1r}}{\sigma_{e1}}\right)^2 + \left[1 + \left(\frac{\sigma_{e1}}{\sigma_{e2}}\right)^2 - \left(\frac{\sigma_{e1}}{\tau_e}\right)^2\right]\left(\frac{\sigma_{1r}}{\sigma_{e1}}\right)\left(\frac{\sigma_{2r}}{\sigma_{e1}}\right) + \left(\frac{\sigma_{e1}}{\sigma_{e2}}\right)^2\left(\frac{\sigma_{2r}'}{\sigma_{e1}}\right)^2 = 1 \qquad (64)$$

Fig. 27 shows variation in the strength ratio σ_{1r}'/σ_{e1} for the various possible values of the stress ratio σ_{2r}'/σ_{e1}. Variations in the strength ratio σ_{1r}'/σ_{e1} are plotted for two possible uniaxial fatigue strength ratios in Fig. 27. Case 1 represents a material with anisotropy, while Case 2 is for an isotropic material with $\sigma_{e1}/\tau_e = 1.73$, the value corresponding to the distortion-energy theory (Equation 62) for $\sigma_{3r}' = 0$. An examination of the plot for Case 1 in Fig. 27 shows that points *A* and *B* have the same value for σ_{1r}'/σ_{e1}. This also follows from the fact, for complete stress reversal under uniaxial stress, the maximum tensile stress must equal the maximum compressive stress.

In a recent paper[58], the author has interpreted test results by the failure relation expressed by

Equation 63. Most available test data for complete stress reversals have been obtained by using solid round specimens subjected to fluctuating torsion and bending. Examination of these data indicates that values of σ_{e2} were not obtained. For this reason is was assumed in the interpretation that $\sigma_{e2} = \sigma_{e1} = \sigma_e$. Then Equation 62 becomes

$$(\sigma_{1r}')^2 + q\,\sigma_{1r}'\,\sigma_{2r}' + (\sigma_{2r}')^2 = \sigma_e^2 \qquad (65.1)$$

where

$$q = 2 - \left(\frac{\sigma_e}{\tau_e}\right)^2 \qquad (65.2)$$

Available test data as given in References 52 to 57 were interpreted by using Equation 65.1. Results of this study are given in detail in Reference 58. The percentage differences and standard deviation between theory and test results were found to be small. The 289 fatigue-stress combinations for the 23 series of tests showed good agreement between theory and tests. Average standard deviation for the 23 series of tests was found to be only 3.6 per cent.

Sawert[56] applied completely reversed axial stresses to a series of differently shaped specimens. By varying the shape of the specimens, he obtained various ratios of principal stresses. Comparison of these test results with the proposed theory shows good agreement (Fig. 28).

Superimposed Static Stresses: The general case of fluctuating stress is represented in Fig. 29, where σ_{1m}, σ_{2m}, and σ_{3m} are mean stresses superimposed on completely reversed stresses σ_{1r}', σ_{2r}', and σ_{3r}' resulting in maximum stresses σ_1', σ_2', and σ_3'.

To formulate theories of failure for an element stressed as shown in Fig. 29, it is necessary to consider failure relations for uniaxial stresses. Proceeding from the straight-line uniaxial fatigue strength relation of Equation 45, Soderberg proposed a *maximum-shear theory of failure for ductile materials* and a *maximum-stress theory for brittle materials*[61]. For biaxial stresses and stress components σ_x, σ_y, and τ_{xy}, the failure relations are given by Equations 66 and 67.

FOR THE MAXIMUM-STRESS THEORY:

$$(\sigma_x' + \sigma_y') - (1-p)(\sigma_x'' + \sigma_y'') \pm \left\{[(\sigma_y' - \sigma_x') - (1-p)(\sigma_y'' - \sigma_x'')]^2 + 4[\tau_{xy}' - (1-p)\,\tau_{xy}'']^2\right\}^{1/2} = \pm 2\,\sigma_e \qquad (66)$$

FOR THE MAXIMUM-SHEAR THEORY:

$$\sigma_x' - (1-p)\,\sigma_x'' = \pm \sigma_e \qquad (67.1)$$

$$\sigma_y' - (1-p)\,\sigma_y'' = \pm \sigma_e \qquad (67.2)$$

or

$$\left\{[(1-p)(\sigma_x'' - \sigma_y'') - (\sigma_x' - \sigma_y')]^2 + 4[(1-p)\,\tau_{xy}'' - \tau_{xy}']^2\right\}^{1/2} = \pm 2\,\sigma_e \qquad (67.3)$$

where $p = \sigma_e/\sigma_{yp}$.

In Equations 66 and 67, the single prime refers to the maximum stress values, while the double primes refer to the mean stresses.

For ductile materials a *distortion-energy theory* for fatigue and superimposed static stresses has been proposed which uses the straight-line failure Equation 45 for uniaxial stress.[62] From this theory, failure for biaxial stresses is defined by

$$[(\sigma_1')^2 - \sigma_1'\,\sigma_2' + (\sigma_2')^2]^{1/2} - (1-p)[(\sigma_1'')^2 - \sigma_1''\,\sigma_2'' + (\sigma_2'')^2]^{1/2} = \sigma_e \qquad (68)$$

In terms of the stress components σ_x, σ_y, and τ_{xy},

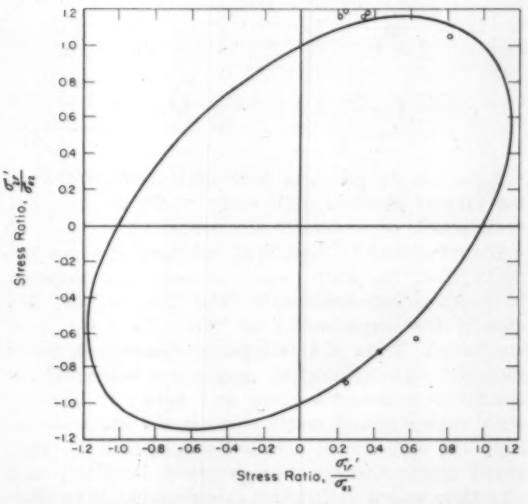


Fig. 28—Comparison of failure theory with Sawert data (annealed mild steel; fatigue strength at 10^7 cycles of reversed stress).

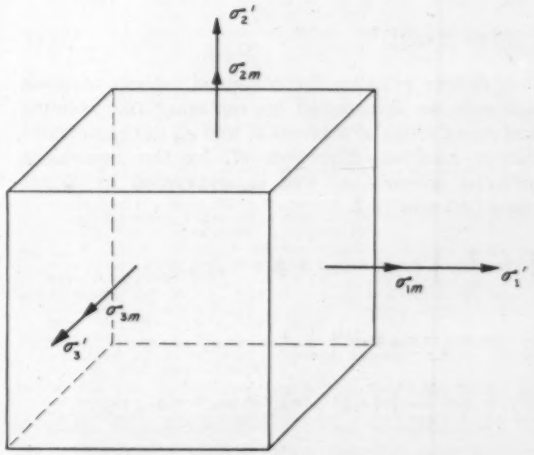


Fig. 29—Fluctuating triaxial stresses.

Equation 68 becomes

$$[(\sigma_x')^2 - \sigma_x'\sigma_y' + (\sigma_y')^2 + 3(\tau_{xy}')^2]^{1/2} - (1-p)[(\sigma_x'')^2 - \sigma_x''\sigma_y'' + (\sigma_y'')^2 + 3(\tau_{xy}'')^2]^{1/2} = \sigma_e \quad (69)$$

The failure relations expressed by Equations 68 and 69 have been used as a basis for defining the working stress in several design codes (References 16, 17, 21). It has been suggested that Mohr's theory be used for brittle materials.[3] Unfortunately not enough test data are available to provide complete support to any one theory. However, test results obtained for ductile materials agree best with the distortion-energy theory (References 63 to 69).

A more accurate interpretation of the test results than is provided by Equation 68 can be obtained if a more accurate representation of uniaxial fatigue failure is used.[58] That is, if the more accurate expression, Equation 47, is used in place of Equation 45, a better comparison between theory and experiment is expected. From this modified theory, failure for combined stresses is also based on the second stress invariant or distortion-energy relation. Failure relations for both isotropic and anisotropic materials can then be expressed as follows.

Fatigue-Strength Relation for Isotropic Materials: A fatigue-strength relation for isotropic materials can be obtained from Equations 25 and 62. If the stress σ_t in Equation 25 is considered as an equivalent uniaxial mean stress σ_m', and the stress σ_e in Equation 62 is considered as an equivalent uniaxial variable stress σ_r', then

$$\sigma_m' = \frac{\sqrt{2}}{2}[(\sigma_{1m} - \sigma_{2m})^2 + (\sigma_{2m} - \sigma_{3m})^2 + (\sigma_{3m} - \sigma_{1m})^2]^{1/2} \quad (70.1)$$

and

$$\sigma_r' = \frac{\sqrt{2}}{2}[(\sigma_{1r} - \sigma_{2r})^2 + (\sigma_{2r} - \sigma_{3r})^2 + (\sigma_{3r} - \sigma_{1r})^2]^{1/2} \quad (70.2)$$

A failure relation for combined fatigue stresses can now be determined by replacing the variable and mean uniaxial stresses σ_r and σ_m in the uniaxial failure relation, Equation 47, by the equivalent uniaxial stresses σ_r' and σ_m expressed by Equations 70.1 and 70.2.

$$\left\{\left(\frac{1}{\sigma_e}\right)[\sigma_{1r}^2 + \sigma_{2r}^2 + \sigma_{3r}^2 - \sigma_{1r}\sigma_{2r} - \sigma_{2r}\sigma_{3r} - \sigma_{3r}\sigma_{1r}]^{1/2}\right\}^n + \left\{\left(\frac{k}{\sigma_u}\right)[\sigma_{1m}^2 + \sigma_{2m}^2 + \sigma_{3m}^2 - \sigma_{1m}\sigma_{2m} - \sigma_{2m}\sigma_{3m} - \sigma_{3m}\sigma_{1m}]^{1/2}\right\}^m = 1 \quad (71)$$

When the ellipse failure expression, Equation 46, is used, Equation 71 for biaxial stresses becomes

$$[\sigma_{1r}^2 - \sigma_{1r}\sigma_{2r} + \sigma_{2r}^2] + \left(\frac{\sigma_e}{\sigma_u}\right)^2[\sigma_{1m}^2 - \sigma_{1m}\sigma_{2m} + \sigma_{2m}^2] = \sigma_e^2 \quad (72)$$

In Equations 71 and 72, it is assumed that the material is isotropic. Modifications in the theory can be made as follows to provide for directional properties.

Fatigue Strength Relation for Anisotropic Materials: For anisotropic materials and biaxial stresses, Equations 28 and 63 are used to obtain the equivalent uniaxial stresses σ_m' and σ_r'. Replacing σ_{t1} by σ_m' and σ_{e1} by σ_r',

$$\sigma_m' = \left\{\sigma_{1m}^2 + \left[1 + \left(\frac{\sigma_{t1}}{\sigma_{t2}}\right)^2 - \left(\frac{\sigma_{t1}}{\tau_s}\right)^2\right]\sigma_{1m}\sigma_{2m} + \left(\frac{\sigma_{t1}}{\sigma_{t2}}\right)^2\sigma_{2m}^2\right\}^{1/2} \quad (73.1)$$

$$\sigma_r' = \left\{\sigma_{1r}^2 + \left[1 + \left(\frac{\sigma_{e1}}{\sigma_{e2}}\right)^2 - \left(\frac{\sigma_{e1}}{\tau_e}\right)^2\right]\sigma_{1r}\sigma_{2r} + \left(\frac{\sigma_{e1}}{\sigma_{e2}}\right)^2\sigma_{2r}^2\right\}^{1/2} \quad (73.2)$$

A failure relation for biaxial fatigue stresses and for anisotropic materials can now be defined by replacing σ_m and σ_r in the uniaxial Equation 47 by the equivalent stresses σ_m' and σ_r' defined by Equations 73.1 and 73.2, and by replacing σ_e and σ_u by σ_{e1} and σ_{t2}, respectively. Then the failure relation becomes

$$\left(\frac{1}{\sigma_{e1}}\right)^n\left\{\sigma_{1r}^2 + \left[1 + \left(\frac{\sigma_{e1}}{\sigma_{e2}}\right)^2 - \left(\frac{\sigma_{e1}}{\tau_e}\right)^2\right]\sigma_{1r}\sigma_{2r} + \left(\frac{\sigma_{e1}}{\sigma_{e2}}\right)^2\sigma_{2r}^2\right\}^{n/2} + \left(\frac{k}{\sigma_{t1}}\right)^m\left\{\sigma_{1m}^2 + \left[1 + \left(\frac{\sigma_{t1}}{\sigma_{t2}}\right)^2 - \left(\frac{\sigma_{t1}}{\tau_s}\right)^2\right]\sigma_{1m}\sigma_{2m} + \left(\frac{\sigma_{t1}}{\sigma_{t2}}\right)^2\sigma_{2m}^2\right\}^{m/2} = 1 \quad (74)$$

Equation 74 provides a fatigue failure relation for biaxial stresses with mean static stresses superimposed on reversed stresses.

Combinations of combined reversed stresses superimposed on static mean stresses are difficult to produce experimentally. For this reason, relatively few experiments of this type have been conducted. Tests of this type that have been made include: (1) cylindrical specimens subjected to combined reversed torsion and reversed bending with superimposed static torsion and static bending; (2) cylindrical specimens subjected to combined static torsion and reversed bending; and (3) thin-walled cylindrical tubes subjected to fluctuating axial tension or compression (References 63 to 70). A comparison of some of these test results with the results predicted by Equation 74,

assuming $n = m = 2$ and $k = 1$, was made by the author (Reference 58). Only approximate agreement between test results and theory was found. The standard deviations for nine series of tests varied between about ± 18 per cent, with an average deviation of about 4 per cent. A better agreement could probably be obtained by using the failure relation expressed by Equation 74 with values of n and m determined for each material in place of the assumption that $n = m = 2$.

Failure relations based on Equations 71 or 74 can also be obtained by expressing fatigue strength for combined stresses in terms of the number of stress cycles and for varying stress amplitudes.

Working-Stress Relations

Fatigue working-stress relations for combined stresses, based on the distortion-energy relation and using the straight-line uniaxial fatigue strength relation, have been proposed by Soderberg[16], Peterson[21] and Marin.[17] For biaxial stresses, failure Equations 68 and 69 are modified replacing the strengths σ_{yp} and σ_e by their allowable values σ_{yp}/N_y and σ_e/N_e. Design relations then become

$$[(\sigma_1')^2 - \sigma_1'\,\sigma_2' + (\sigma_2')^2]^{1/2} - \left(1 - p\,\frac{N_e}{N_y}\right)[(\sigma_1'')^2 - \sigma_1''\,\sigma_2'' + (\sigma_2'')^2]^{1/2} = \frac{\sigma_e}{N_e} \quad (75)$$

$$[(\sigma_x')^2 - \sigma_x'\,\sigma_y' + (\sigma_y')^2 + 3(\tau_{xy}')^2]^{1/2} - \left(1 - p\,\frac{N_e}{N_y}\right)[(\sigma_x'')^2 - \sigma_x''\,\sigma_y'' + (\sigma_y'')^2 + 3(\tau_{xy}'')^2]^{1/2} = \frac{\sigma_e}{N_e} \quad (76)$$

Biaxial working-stress relations based on the proposed failure Equations 71 and 74 can be obtained by replacing the uniaxial strength values in these equations by their allowable values. Resulting design relations are given by Equations 77 and 78.

For Isotropic Materials:

$$\left[\frac{N_e}{\sigma_e}\left(\sigma_{1r}^2 - \sigma_{1r}\,\sigma_{2r} + \sigma_{2r}^2\right)^{1/2}\right]^n + \left[\frac{k\,N_u}{\sigma_u}\left(\sigma_{1m}^2 - \sigma_{1m}\,\sigma_{2m} + \sigma_{2m}^2\right)^{1/2}\right]^m = 1 \quad (77)$$

For Anisotropic Materials:

$$\left(\frac{N_{e1}}{\sigma_{e1}}\right)^{1/n}\left\{\sigma_{1r}^2 + \left[1 + \left(\frac{\sigma_{e1}\,N_{e2}}{\sigma_{e2}\,N_{e1}}\right)^2 - \left(\frac{\sigma_{e1}\,N_r}{\tau_e\,N_{e1}}\right)^2\right]\sigma_{1r}\,\sigma_{2r} + \left(\frac{\sigma_{e1}\,N_{e2}}{\sigma_{e2}\,N_{e1}}\right)^2 \sigma_{2r}^2\right\}^{n/2} + \left(\frac{k\,N_{u1}}{\sigma_{t1}}\right)^{1/m}\left\{\sigma_{1m}^2 + \left[1 + \left(\frac{\sigma_{t1}\,N_{t2}}{\sigma_{t2}\,N_{t1}}\right)^2 - \left(\frac{\sigma_{t1}\,N_s}{\tau_s\,N_{t1}}\right)^2\right]\sigma_{1m}\,\sigma_{2m} + \left(\frac{\sigma_{t1}\,N_{t2}}{\sigma_{t2}\,N_{t1}}\right)^2 \sigma_{2m}^2\right\}^{m/2} = 1 \quad (78)$$

where N values represent the appropriate factors of safety for each uniaxial stress.

Equations 75 to 78 can be used as a design basis for members without stress concentration when the stress components are replaced by their values in terms of the loads and dimensions of the members. Methods of calculation are described in References 15, 21 and 1.

In the next part of this series, methods of providing for stress concentration will be discussed.

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HYDRAULIC SERVOS—2

Practical methods for analyzing typical systems

By J. M. Nightingale
Manchester, England

VALVE-CYLINDER relays are among the most widely used servo units. Analysis of such a unit, Fig. 5, was started in the first part of this article. Loop and overall transfer functions of the system were developed by considering small variations. In this part of the article, the functions developed will be used to investigate performance of the servo.

Stability: As always stability must be the first consideration. It can be shown that the worst conditions for absolute stability exist when the cylinder piston is in its midposition and when the output load is simply an inertia force. In this case, from Equation 12,

$$\xi(s) = ms^2 \qquad (15)$$

By substituting this value in Equations 13 and 14, loop and overall transfer functions for this condition are obtained.

$$Y_o(s) = \frac{K}{s\left(1 + \frac{Kms}{\lambda_v} + \frac{ms^2}{\lambda_c}\right)} \qquad (16)$$

$$Y_c(s) = \frac{K}{\left(K + s + \frac{Kms^2}{\lambda_v} + \frac{ms^3}{\lambda_c}\right)} \qquad (17)$$

From these expressions stability can easily be investigated by the Hurwitz criterion. This gives as the necessary condition $Km/\lambda_v > Km/\lambda_c$, or

$$\lambda_c > \lambda_v \qquad (18)$$

This criterion can be interpreted physically as follows. If output inertia load increases, then the fluid column in the cylinder will shorten, because of compressibility, causing relative movement between the valve casing and spool. The resulting valve opening causes a change in the differential cylinder pressure. The change in effort produced by this must not exceed the change in the output load. If the valve does over-compensate for the change in load, then the cylinder will move back and a continuous cycle will be set up.

To get sufficiently low valve stiffness to satisfy this condition there must be some constant leakage past the valve lands. Two possible ways of achieving this are by means of underlap or overlap at the valve ports, Fig. 6. Within the region of valve lap the ports act as a variable-resistance bridge. Differential pressure depends on the resistance ratios and hence on the relative valve displacement. If no lap is provided, a very small valve displacement applies full system pressure across the cylinder piston, with resulting over-correction.

Even if stability is not satisfied, it does not

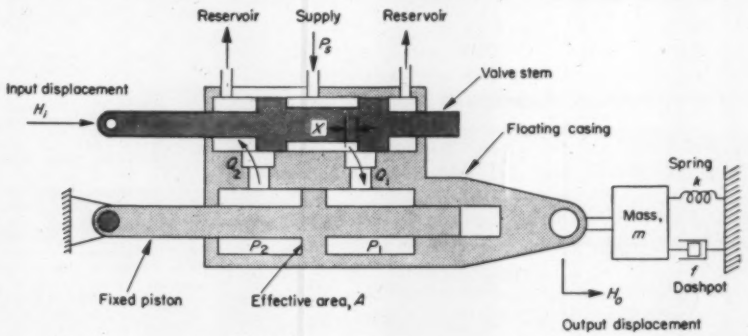


Fig. 5 — Valve-cylinder servos of this type are widely used. Stability and response of this type of servo are analyzed in this article.

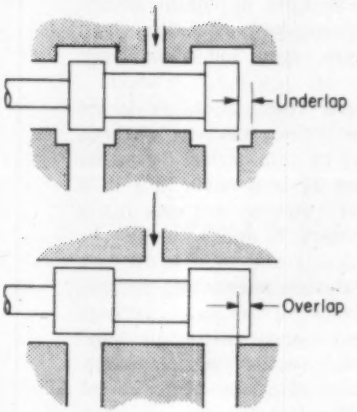


Fig. 6—Left—Valve stiffness in the neutral position may be reduced by either underlap or overlap. Underlap signifies that the valve spool does not completely close the ports when the spool is centered. Overlap means that the valve spool lands exceed the width of the ports.

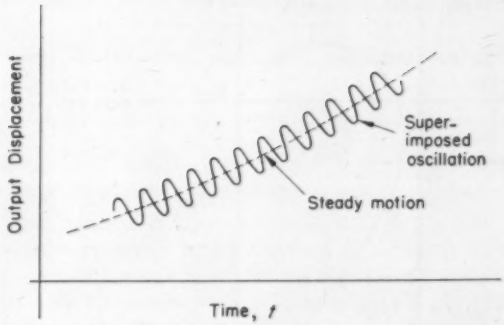


Fig. 7—Oscillation does not necessarily increase indefinitely. It may be a small, steady oscillation superimposed on the steady output motion of the servo.

necessarily mean that an oscillation can grow indefinitely because the equations deal only with very small movements. As the amplitude increases, parameters K and λ_v will change sufficiently to restore stability, although this may not happen until the valve ports are fully exposed and the system saturates. This means that a steady oscillation will be superposed on the steady-state motion, Fig. 7. In practice it has been found satisfactory from the stability viewpoint to satisfy Equation 18 for all possible values of X within the range of maximum travel in either direction and for all possible values of P_c within the range of allowable output loading.

Response: Satisfactory response within the linear zone of the servo is also very important. As previously established[8], response characteristics are seriously impaired by flow-saturation outside the linear zone. Provided small motions only are considered, Equation 17 can be used to obtain response characteristics. If a sudden step from one steady demand to another which is quite close to the first occurs, the output should respond quickly and without too much oscillation, Fig. 8. It must be stressed that for large disturbances the prob-

[8]References are tabulated at end of article.

Nomenclature

A = Effective cylinder piston area
a = Total exposed port area
b = Constant describing increase of exposed port area with valve travel
C = Flow constant
$f(X)$ = Function describing how exposed valve port area varies with X
G = Gain margin
h = Lap each side of valve land
K = Slope gain constant
L = Cylinder stroke
M_1 = Maximum amplitude ratio
m_t = Output load inertia
N = Bulk modulus of fluid
P_c = Differential cylinder pressure
$P_{c\ max}$ = Maximum value of P_c
P_s = Supply pressure
s = Laplace operator
X_m = Maximum effective valve travel from neutral
$Y_c(s)$ = Overall transfer function
$Y_o(s)$ = Loop transfer function
θ_i = Incremental input displacement
θ_o = Incremental output displacement
λ_c = Cylinder stiffness
λ_v = Valve stiffness
$\xi(s)$ = Dynamic stiffness
ω = Angular frequency
ω_b = Bandwidth frequency

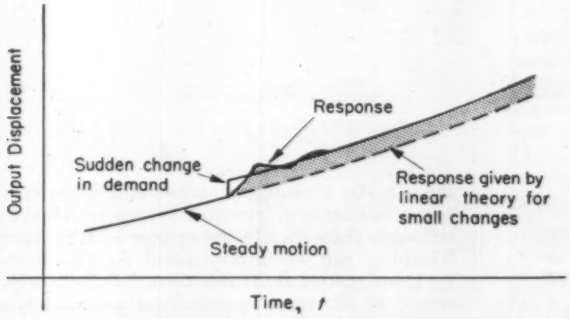


Fig. 8 — If established response requirements are met, servo response will be quick and well damped. Although a small change in required output is considered, response to large changes in output requirement may be similar.

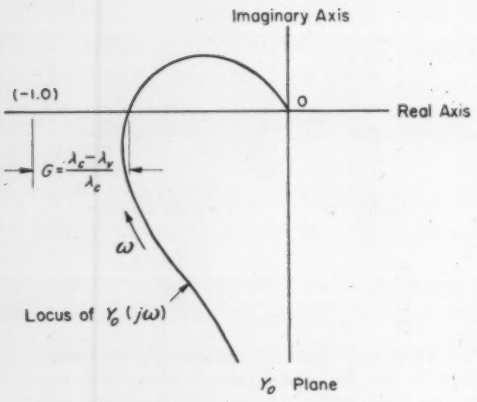


Fig. 9—Typical Nyquist plot for a hydraulic relay. A change in gain constant, K, can alter the shape as well as the scale of the plot. This often happens in systems where interaction occurs.

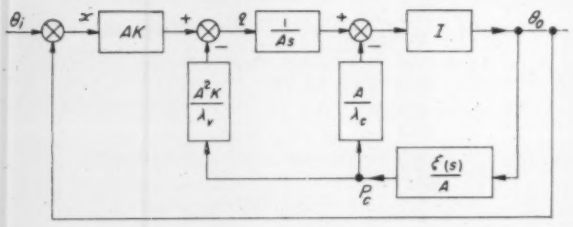


Fig. 10—Subsidiary feedback loops in this block diagram of a hydraulic relay represent interaction between components. The diagram represents Equations 8, 9 and 12.

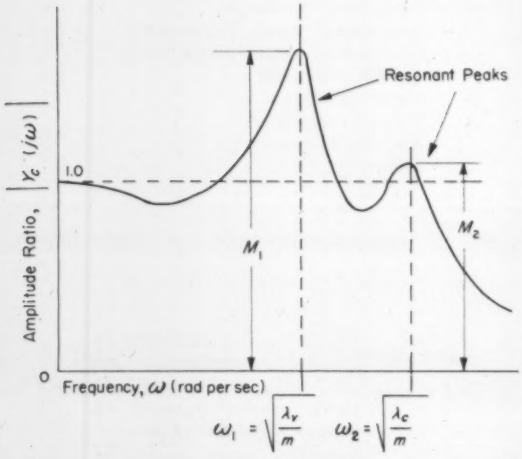


Fig. 11—A plot of amplitude ratio versus frequency shows that there are generally two resonant frequencies. The two peaks must not coincide or the system will be unstable. Ordinarily ω_2 should be larger than 2 ω_1.

lem really belongs to the field of nonlinear mechanics. Yet it is surprising how close the small perturbation methods are, even for quite large disturbances.

To investigate response from Equation 16 or 17, it is possible to use linear analysis methods outlined in earlier parts of this series. Since the denominator of Equation 17 is a cubic in s it is possible to use transient response methods fairly simply. However parameters K and λ_v cannot be easily adjusted independently and so it is difficult to attempt to optimize design parameters by this technique. Therefore, frequency response methods will be used. As system equations become more complicated, it is helpful to use this approach.

Substituting $j\omega$ for s in Equation 16 gives the loop harmonic response function for the case when the load is simply an inertia.

$$Y_o(j\omega) = \frac{K}{j\omega\left(1 - \frac{m\omega^2}{\lambda_c} + \frac{j\omega Km}{\lambda_v}\right)} \qquad (19)$$

From this a Nyquist plot can be made, Fig. 9. As Equation 19 shows, a change in K not only alters the scale of the diagram, but also the shape of the $Y_o(j\omega)$ curve. This is often a feature of systems in which there is interaction, as between output load and valve flow here. This interaction is represented by subsidiary feedback loops in the block diagram, Fig. 10.

Loop phase angle is -180 deg when $\omega = \sqrt{\lambda_c/m}$, from which it follows that the gain margin is

$$G = \frac{\lambda_c - \lambda_v}{\lambda_c} \qquad (20)$$

Note that the gain margin is zero at the critical stability condition defined by Equation 18, as might be expected. A suitable value is $G = 0.75$ and this yields $\lambda_v = 0.25\ \lambda_c$. This criterion is satisfactory in this case because of the simple shape

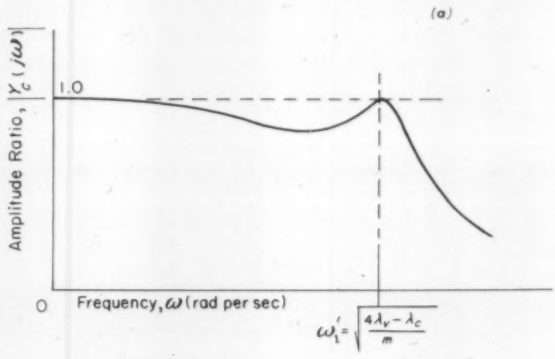


Fig. 12—By limiting maximum amplitude ratio to 1.0, a satisfactory, practical system is achieved, *a*, although theoretically the system is over damped. Damping can be incorporated to eliminate all resonant points, *b*. In this case, transient response would be far too sluggish for a practical system.

of the locus, but it is not always so convenient and it is not wise to use it as a purely algebraic criterion without constructing the Nyquist plot.

Now by adjusting the value of K it is possible to achieve a suitable phase margin. By making the phase margin 45 deg, the optimum gain constant is

$$K = 1.2 \sqrt{\frac{\lambda_v}{m} \left(1 - \frac{\lambda_v}{\sqrt{2}\,\lambda_c} \right)}$$

This is an easy method when numerical data are available, but when dealing with algebraic expressions it can become tedious. It is generally true that algebraic expressions become tedious when dealing with complicated systems in a perfectly general way. In the present case when certain of the parameters, such as K and λ_v, can assume widely varying values, depending on the particular steady-state condition chosen, it is very helpful from the standpoint of understanding system behavior to work with algebraic expressions. In this connection some useful approximations can often be made.

From the overall harmonic response function

$$Y_c(j\omega) = \frac{K}{K \left(1 - \frac{m\omega^2}{\lambda_v} \right) + j\omega \left(1 - \frac{m\omega^2}{\lambda_c} \right)} \qquad (21)$$

the amplitude response is

$$\left| \frac{\theta_o}{\theta_i} (j\omega) \right| = \frac{K}{\sqrt{K^2 \left(1 - \frac{m\omega^2}{\lambda_v} \right)^2 + \omega^2 \left(1 - \frac{m\omega^2}{\lambda_c} \right)^2}} \qquad (22)$$

This may be plotted against frequency, Fig. 11. The response tends to two resonant peaks at frequencies very approximately given by $\omega_1 = \sqrt{\lambda_v/m}$ and $\omega_2 = \sqrt{\lambda_c/m}$. Thus the stability criterion can be written as $\omega_1 < \omega_2$. If $\omega_1 = \omega_2$, the two peaks will merge into a single peak of infinite height, indicating that the output will increase indefinitely at this frequency of excitation.

If $\omega_2 > 2\omega_1$, the peaks are quite separate and compressibility will have little influence on the maximum amplitude ratio which occurs at ω_1. Note that this condition is the same as the one implied by the foregoing gain margin criterion. If this is satisfied then the maximum amplitude ratio is approximately

$$M_1 = \frac{\frac{\omega_2 K}{\omega_1}}{\sqrt{\omega_2^2 - \omega_1^2}} \qquad (23)$$

This relation is more accurate for $M_1 > 1.5$. If ω_2 is very much larger than ω_1, $K = M_1\omega_1$. Since ω_1 is some measure of the bandwidth, this shows that K influences both maximum amplitude ratio and bandwidth. Putting $M_1 = 1.5$ in Equation 23 gives the optimum gain as

$$K = 1.5 \sqrt{\frac{\lambda_v}{m} \left(1 - \frac{\lambda_v}{\lambda_c} \right)}$$

This is slightly higher than that given by the phase margin criterion.

In practical cases it may not be possible to isolate ω_1 and ω_2 sufficiently to make these approximations. In this case, exact and more tedious algebraic expressions must be used. Great simplification can be achieved if the maximum amplitude ratio is limited to $M_1 = 1.0$. Although in theory this tends to give an overdamped, sluggish response, practical results indicate that the choice is satisfactory in the present case. Optimum gain constant in this case is

$$K = \frac{2\,\lambda_v}{\lambda_c} \sqrt{\frac{\lambda_c - 2\,\lambda_v}{m}} \qquad (24)$$

From the response curve, Fig. 12*a*, it can be seen that the peak occurs at a frequency given by

$$\omega_1 = \sqrt{\frac{4\,\lambda_v - \lambda_c}{m}} \qquad (25)$$

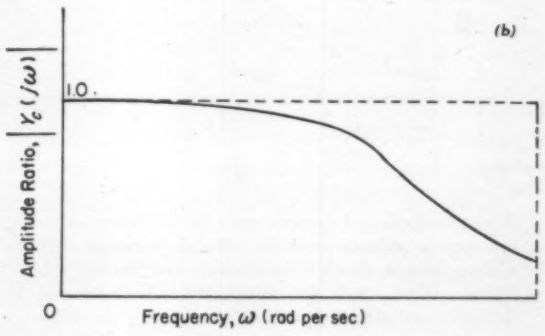
In this case the unit is so heavily damped that no second peak occurs. If $\lambda_v < 0.25\,\lambda_c$, there will be no resonant peak, Fig. 12 *b*, but the actual transient response will be far too sluggish.

The preceeding analysis shows that the relationship between λ_c and λ_v is critical for stability. In practice it may be difficult to increase λ_c so as to isolate compressibility effects from the operating range. Stiffness of the fluid column in the cylinder is

$$\lambda_c = \frac{4\,AN}{L} \qquad (26)$$

Thus to increase λ_c the jack stroke should be kept as short as possible and the area, A, as large as possible. Also N should be kept as high as possible. Under actual operating conditions the hydraulic fluid will absorb air bubbles which will be suspended in the fluid. This tends to lower the effective N according to the volumetric fraction of air contained. A typical variation of N with pressure, Fig. 13, shows that increasing pressure is an advantage. This suggests the possibility of maintaining the fluid in the cylinder at a base pressure.

Since minimum pressure on either side of the cylinder occurs under maximum output load and is $(P_s - P_{c\,max})/2$, it is desirable to limit $P_{c\,max}$



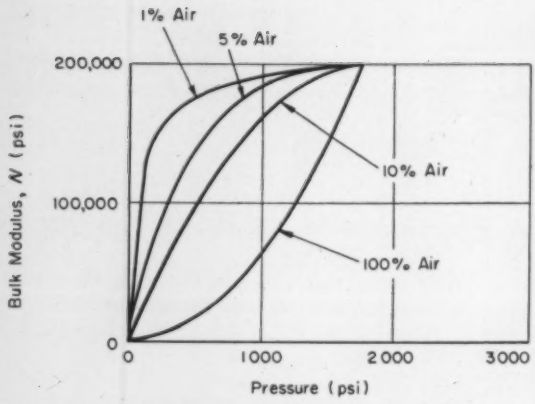


Fig. 13—Bulk modulus of hydraulic fluid varies with percentage of entrained air and system pressure. A low bulk modulus can adversely affect servo system stability. High pressures are advantageous for this reason.

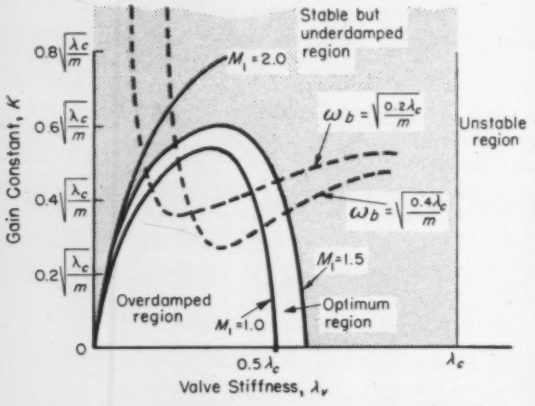


Fig. 14 — To investigate servo performance under all possible conditions, lines of constant maximum amplitude ratio, M_1, and constant bandwidth, ω_b, are plotted on the K, λ_v plane.

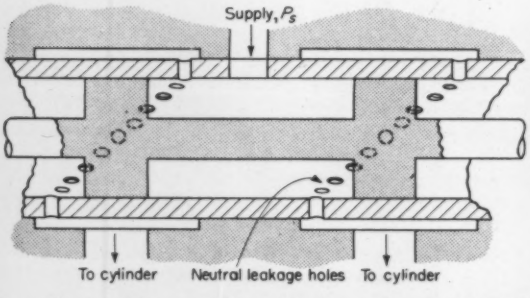


Fig. 15—One way of achieving a linear variation of valve opening with spool movement is to make the port a row of staggered radial holes rather than a single opening. With this method, it is possible to achieve almost any desired flow characteristic by varying hole size and spacing.

It was previously suggested that $P_{c\,max}$ be limited to $2/3P_s$ by power considerations. This gives a minimum pressure of $P_s/6$ in the cylinder—normally a satisfactory value. Such a base pressure can be maintained by neutral-lap leakage past the valve lands.

Physical Parameters: Results thus far have been obtained in terms of two rather unreal parameters K and λ_v. Now these results must be related to physical design parameters. As previously stated, response and stability must be investigated for all possible combinations of these two parameters.

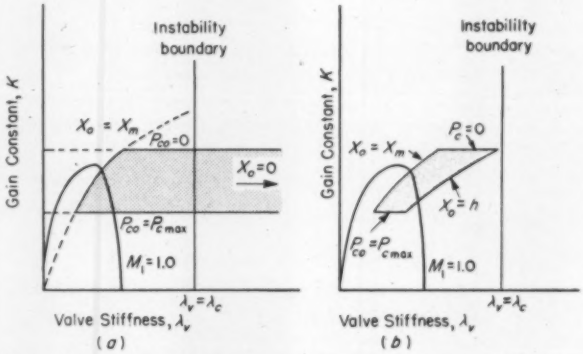


Fig. 16—Superimposition of actual valve operating conditions on the K, λ_v plane shows, *a*, how a system using a valve with no overlap or underlap becomes unstable when the spool is in neutral position. Use of lap on valve lands, *b*, permits the system to be kept out of the unstable region.

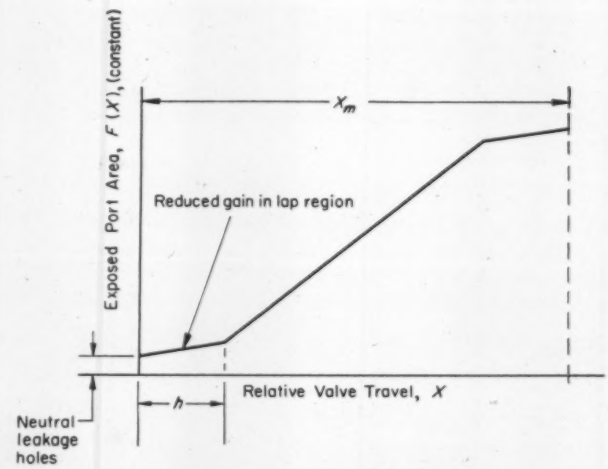


Fig. 17—Reduced system gain in the valve-lap region reduces leakage but also produces a sluggish or dead zone in the system response. This tends to reduce the effect of dynamic output load variations.

To do this work the concept of a K, λ_v plane containing all possible values is necessary. On this plane it is possible to plot contours representing the stability limit and also lines of constant M_1 and constant bandwidth ω_b, Fig. 14.

By superimposing on this diagram characteristics representing the limits of linear operation it is possible to inspect performance at all steady operating points. Previously[8], it was assumed that the exposed port area varies linearly with relative valve travel. Normally this will not be so unless a deliberate attempt is made to control this relationship. One possible way is by making the valve port a row of staggered radial holes, Fig. 15. In this way it is possible to control the flow characteristics of the valve and achieve, within reason, an approximation to any function, $f(X)$.

First assume a function $f(X) = bX$, where $b = Ca/X_m$. Here C is a flow constant which may be taken as 100 if English units (lb-in.-sec) are used and a is the maximum exposed port area corresponding to maximum valve displacement from neutral, X_m. It will later be seen desirable to deliberately modify this arrangement slightly. Equation 5 then becomes

$$Q = bX\sqrt{\frac{P_s - P_c}{2}} \tag{27}$$

From which it follows that

$$K = \frac{b\sqrt{P_s - P_{co}}}{A\sqrt{2}} \tag{28}$$

$$\lambda_v = \frac{2A(P_s - P_{co})}{X_o} \tag{29}$$

The range of possible operating conditions is given by $0 \leq X_o \leq X_m$; $0 \leq P_{co} \leq P_{c\,max}$. Lines of constant P_{co} are parallel to the λ_v axis, Fig. 16. Lines of constant X_o are given by

$$K = \sqrt{\frac{\lambda_v X_o}{2A^3}} \tag{30}$$

Substituting the extreme values of X_o and P_{co} defines the shaded region in Fig. 16. It is now easy to see how the performance varies for all possible operating conditions.

From Equation 29 it can be seen that in the neutral position, i.e. where $X_o = 0$, the valve stiffness λ_v becomes infinite. Hence in theory the stability criterion is not satisfied. This is confirmed in practice by the continuous hunting of many valve-cylinder servos in the neutral region. Stability can be achieved by providing lap at the valve lands. If h is the lap per side, Fig. 6, then within the lap region the valve stiffness does not differ greatly from $\lambda_v = A(P_s - P_{co})/h$. The minimum lap necessary to just satisfy the stability condition, Equation 18, is therefore given by

$$h = \frac{P_s L}{4N} \tag{31}$$

The disadvantage of using lap is the continuous leakage loss past the lands. A way of reducing this is to make the exposed port area increase only slightly within the lap stroke of the valve. In other words the values of b and, therefore, K are reduced near the neutral position. This tends to make the unit very sluggish near neutral with a very low cut-off frequency. One advantage of this is that the effect of dynamic output load variations is greatly reduced. Variation of $f(X)$ with X will then take the form shown in Fig. 17.

Region of operating points on the K, λ_v plane is now modified, Fig. 16*b*. Even now it may be difficult to get the region well away from the instability boundary without using execessively wide lap strokes on the valve. A better way of achieving stability and a more economic one is by means of a small leak across the cylinder piston together with a region of reduced gain near the neutral valve position. This will be further discussed in a later article.

NUMERICAL EXAMPLE: For the servo previously discussed[8] where $P_s = 3000$ psi, $F_m = 4000$ lb, $L = 2.0$ in., $T_n = 0.25$ sec, $\omega_b = 80$ rad per sec, $A = 2.0$ sq in., $a = 0.0039$ sq in., $Q_n = 16$ cu in. per sec and $X_m = 0.1$ in. were assumed or established, assume that $m = 2.0$ lb sec^2 per in. and $N = 80{,}000$ psi. Then from Equation 26 $\lambda_c = 320{,}000$ lb per in. From Equation 31 the minimum lap per side is $h = 0.018$ in. This just maintains stability, but would give an underdamped response. At least twice this amount of lap would be required for adequate stability and would give a wide deadband. A typical response-amplitude curve is shown in Fig. 18 for values of $X_o = X_m/2$ and $P_{co} = 2/3\ P_s$. These values give $K = 43.7$ and $\lambda_v = 80{,}000$. On the same graph is plotted the approximate response curve given by the simplified methods of the earlier analysis.[8]

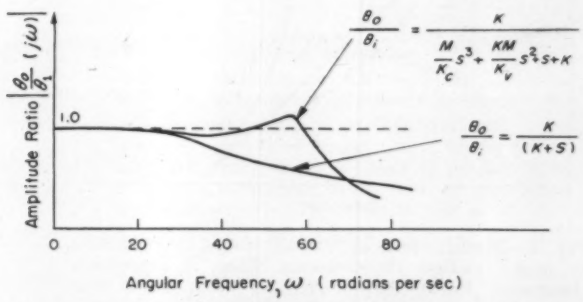


Fig. 18—Amplitude ratio curves for a hydraulic relay determined by, *a*, small perturbation methods and, *b*, by the simplified methods used in an earlier analysis.

REFERENCES

This article is the tenth in a co-ordinated group by J. M. Nightingale on servo systems. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

1. "Automatic Control Systems" ..... May 17, 1956
2. "Servo Mathematics" ..... June 28, 1956
3. "Evaluating Servo System Performance—Part 1" ... July 26, 1956
4. "Evaluating Servo System Performance—Part 2" ... Aug. 9, 1956
5. "Analyzing Servo Systems" ..... Nov. 1, 1956
6. "Hydraulic Servo Components—Part 1" ..... Nov. 29, 1956
7. "Hydraulic Servo Components—Part 2" ..... Dec. 13, 1956
8. "Hydraulic Servo Components—Part 3" ..... Dec. 27, 1956
9. "Hydraulic Servos—Part 1" ..... Feb. 21, 1957

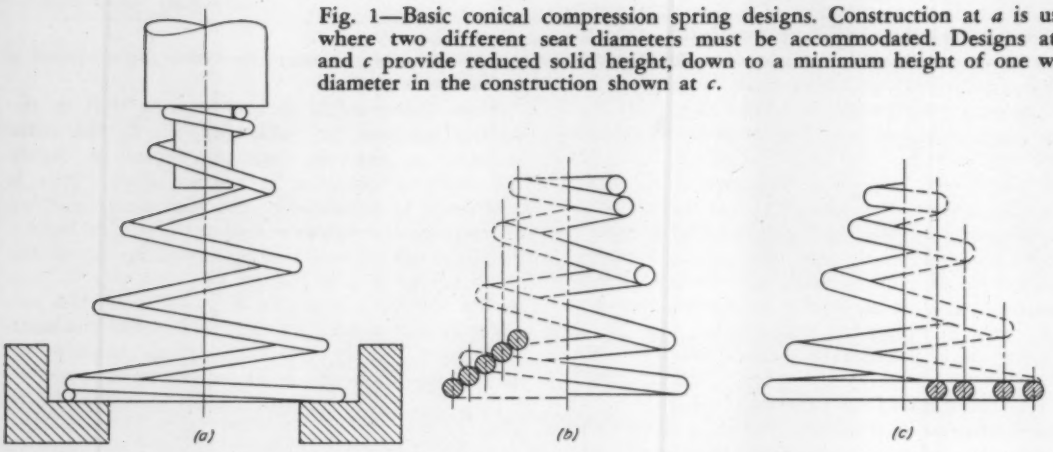


Fig. 1—Basic conical compression spring designs. Construction at *a* is used where two different seat diameters must be accommodated. Designs at *b* and *c* provide reduced solid height, down to a minimum height of one wire diameter in the construction shown at *c*.

SPECIAL SPRING FORMS

Although use of the most simply formed cylindrical spring is recommended wherever possible, springs with other shapes are sometimes more suitable in certain applications. Four common types of specially shaped springs are presented here, with their basic design formulas and the principles of their design and application.

TYPES of specially shaped springs that merit particular consideration in design include: (1) conical, (2) barrel, (3) oval and (4) garter. All of these spring shapes can be coiled on standard spring coilers and need not be prohibitively expensive to manufacture.

Conical Springs: Two requirements satisfied by conical compression springs are: (1) when the design of the mechanism requires the spring to seat at two radically different diameters, Fig. 1*a*; and (2) when the spring must have a reduced solid height, down to and including a minimum of one wire diameter, Figs. 1*b* and *c*.

Design of conical springs is based on the following formulas (symbols are defined in Nomenclature):

$$K = \frac{P}{F} = \frac{Gd^4}{16N(r_1^2 + r_2^2)(r_1 + r_2)} \quad (1)$$

$$S = \frac{16\,PR_1\,r}{\pi\,d^3} \quad (2)$$

$$S_{max} = \frac{16\,PR_1\,r_2}{\pi\,d^3} \quad (3)$$

where r_1 is the mean radius of the smallest coil, r_2 is the mean radius of the largest coil and r is the mean coil radius at point where stress is of interest.

Calculated gradients for conical springs can seldom be attained in manufacture because the springs can almost never be made so that all coils become inoperative simultaneously. This is especially true if, as is the case with most conical springs, the ends are squared. Thus, actual conical spring gradients will not be linear as the equation would

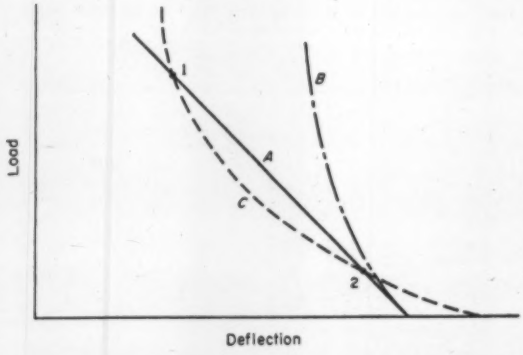


Fig. 2—Modification of conical spring construction to match design requirements. Line *A* represents theoretical linear load-deflection relationship; line *B* is probable actual condition for spring manufactured according to design calculations; and line *C* is the result achieved with a modified construction in which the wire diameter has been reduced to produce a "softer" spring action.

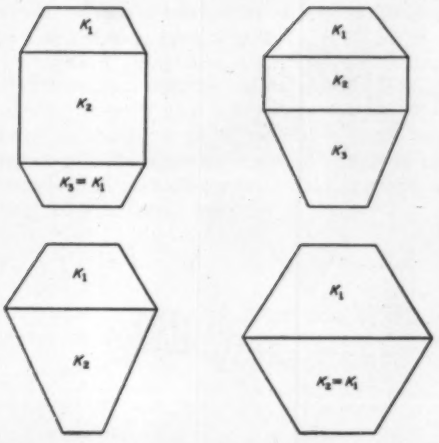


Fig. 3—Basic forms of barrel springs.

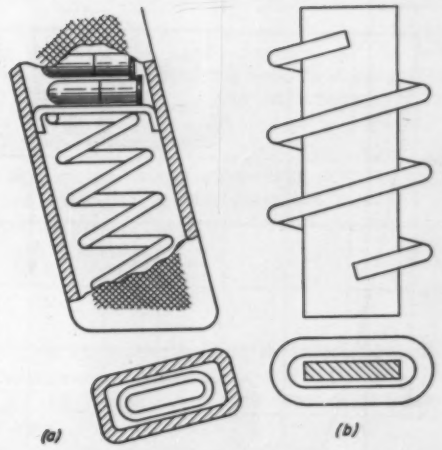


Fig. 4—Typical applications of oval springs: *a*, compression spring in magazine cartridge feed and *b*, compression and extension spring supported by a flat bar.

By Frank A. Votta Jr., *Chief Engineer*
Hunter Spring Co., Lansdale, Pa.

indicate. For example, if test points 1 and 2 in Fig. 2 were specified, design calculation would give a spring with the gradient indicated by line *A*. However, the spring when manufactured would probably have a gradient similar to line *B*. To match the specified test points a "softer" spring would usually be designed by reducing wire diameter so that the gradient will meet the test criteria (line *C*).

Ends of conical springs which compress to one wire diameter ("pancake") should never be squared and ground. To square and grind an end, the last coil must overlap the adjacent coil. This precludes pancaking.

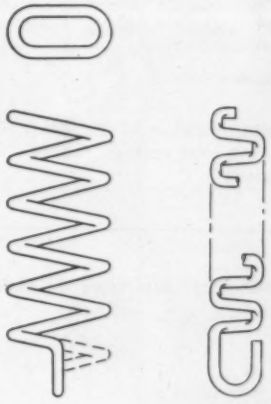


Fig. 5—Method of forming hooks in oval extension springs.

Nomenclature

D = Mean coil diameter (outside diameter of coil minus wire diameter), in.
d = Wire diameter, in.
F = Deflection between operating lengths, in.
G = Torsional modulus of elasticity, psi
H = Free length of spring (includes hooks on extension springs to point of contact with other members), in.
K = Spring rate or gradient, lb per in.
N = Number of active coils
P = Load, lb
P_1 = Initial load, lb
R_1 = Stress concentration factor in shear for round wire
S = Basic stress, psi
S_{max} = Maximum solid stress, psi

Barrel Springs: Outlines of some basic forms of barrel springs are shown in Fig. 3. These springs are merely combinations of springs with conical ends and, with or without, a central portion of constant diameter. The conical ends need not be identical. Barrel springs are commonly used (1) to provide conveniently small ends while maintaining a required gradient or a straight body diameter, (2) to provide a large deflection with small solid height through the nesting or pancaking of the conical ends, and (3) to prevent buckling.

In design calculations, barrel springs are treated as separate conical and straight springs in series. Thus,

$$K = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3}} \qquad (4)$$

where K is the overall gradient and K_1, K_2 and K_3

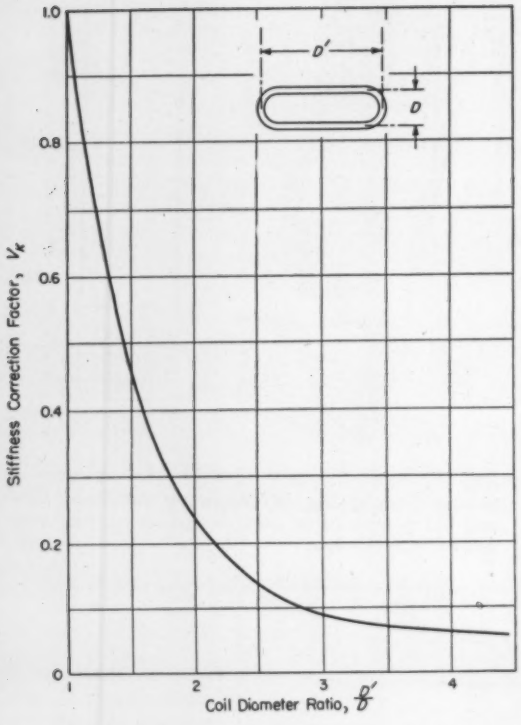


Fig. 6—Chart for determination of stiffness correction factor V_K for oval springs. Curve plot is based on Equation 7.

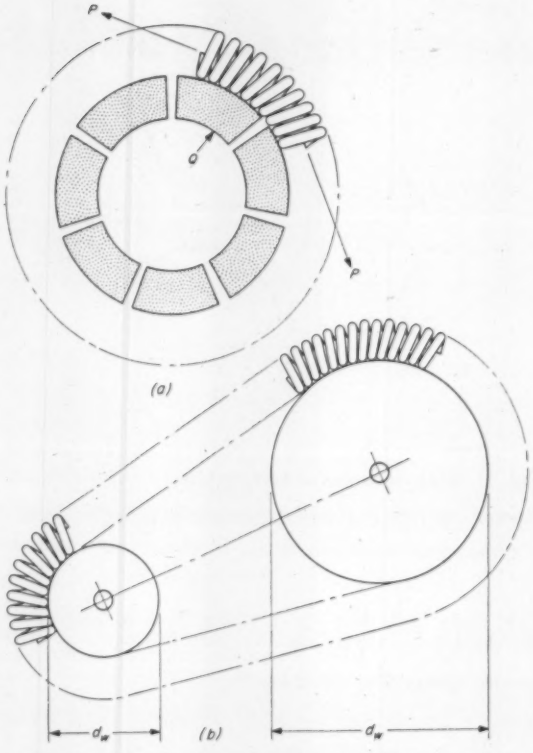


Fig. 7—Typical garter-spring applications. At *a*, radial forces exerted by spring are used to contract several circular segments. At *b*, spring serves as a drive belt between two pulleys.

are gradients of the individual sections. If ends are identical, $K_1 = K_3$ and

$$K = \frac{1}{\frac{2}{K_1} + \frac{1}{K_2}} \qquad (5)$$

Maximum solid stress is given by

$$S_{max} = \frac{8\,PDR_1}{\pi\,d^3} \qquad (6)$$

where D is the mean diameter, in., of the largest active coil.

Oval Springs: Occasionally, space considerations will require the use of an oval spring, which is merely a spring flattened on opposite sides. Oval springs can be manufactured in large quantities on standard spring coilers by the use of special attachments. Or, in smaller quantities, they can be hand wound on twisted bar arbors, the twist allowing for springback.

Common applications are as compression springs in magazine cartridge feeds, Fig. 4*a*, and as both compression and extension springs supported by a flat bar, Fig. 4*b*. Hooks of oval extension springs

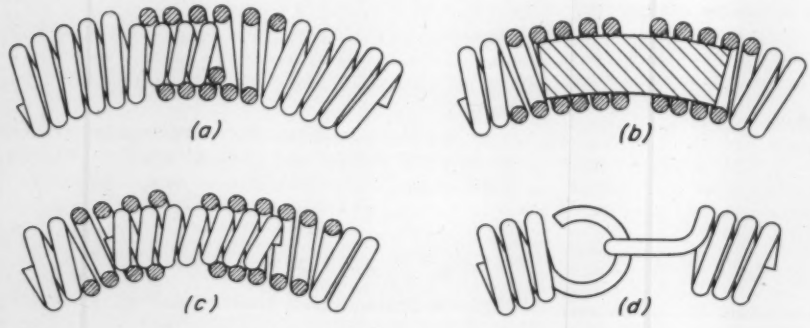


Fig. 8—Typical end connections for garter springs showing: *a*, reduced end section for direct attachment; *b*, threaded plug assembly; *c*, spring "plug" assembly; and *d*, interlocked hooks assembly.

are most easily formed by simply bending one-half of the last oval turn, Fig. 5.

Standard compression and extension spring design formulas may be used for oval springs by employing a stiffness correction factor, V_K, based only on the ratio D'/D, where D' is the maximum mean coil diameter of the oval and D is the minimum mean coil diameter. This correction factor may be calculated from:

$$V_K = \left(\frac{D'}{D}\right)^{-2.1} \quad (7)$$

This equation is solved graphically in Fig. 6. Other design equations for oval springs are

$$K = \frac{Gd^4 V_K}{8 D^3 N} \quad (8)$$

$$S = \frac{8 PD' R_1}{\pi d^3} \quad (9)$$

To find the stress concentration factor, R_1, for an oval spring, use D/d, not D'/d, as the spring index.

Garter Springs: Another useful form is that offered by garter springs, which are simply extension springs, usually close-wound, with their ends connected. They are used to exert a contracting force on shafts, segments, protrusions, or pulleys. Common applications include oil and grease seals, chucks and flexible diaphragm frames. In addition, they are used as spring belts to drive pulleys, as in motion picture projectors. Typical garter spring or spring-belt applications are shown in Fig. 7.

Garter spring design formulas are based on standard extension spring formulas modified for the particular application. Using the notations from Fig. 7*a* gives:

$$Q = 2P \sin\left(\frac{180}{n}\right) \quad (10)$$

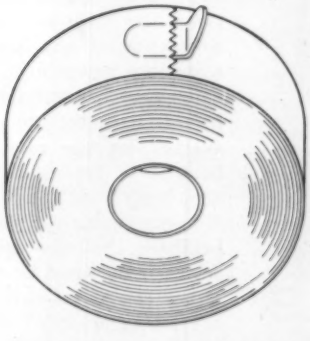
where Q is the radial load in lb on each segment, n is the number of segments, and P is the axial load in lb on the spring when considered as an extension spring.

Commonly used end connections for garter springs are illustrated in Fig. 8. In Fig. 8*a*, one end of the spring has been reduced in diameter to screw into the other end. Plugs may be used to join opposite ends. The plug may be solid, tubular or threaded as in Fig. 8*b*, or it may even be a separate spring of smaller diameter as in Fig. 8*c*. The interlocked hooks shown in Fig. 8*d* are probably the simplest method of joining opposite ends of a garter spring.

Tips and Techniques

Keeping Tape End Free

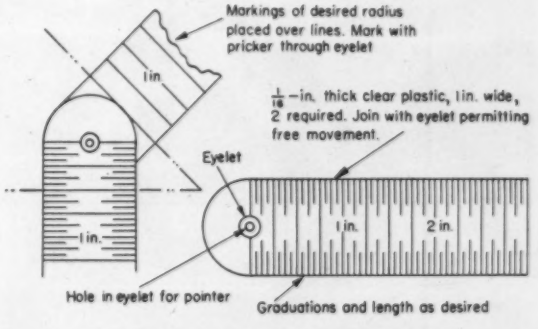
Much time can be spent trying to find the free end of a roll of masking or cellophane tape when



the end is stuck to the roll. A small sheet-metal clip fastened to the end of the tape when it is not in use will eliminate this difficulty.—WILLIAM R. LOCKE, *Cincinnati, Ohio.*

Locating Centers

Two plastic scales fastened together with an eyelet as shown make a very useful device for

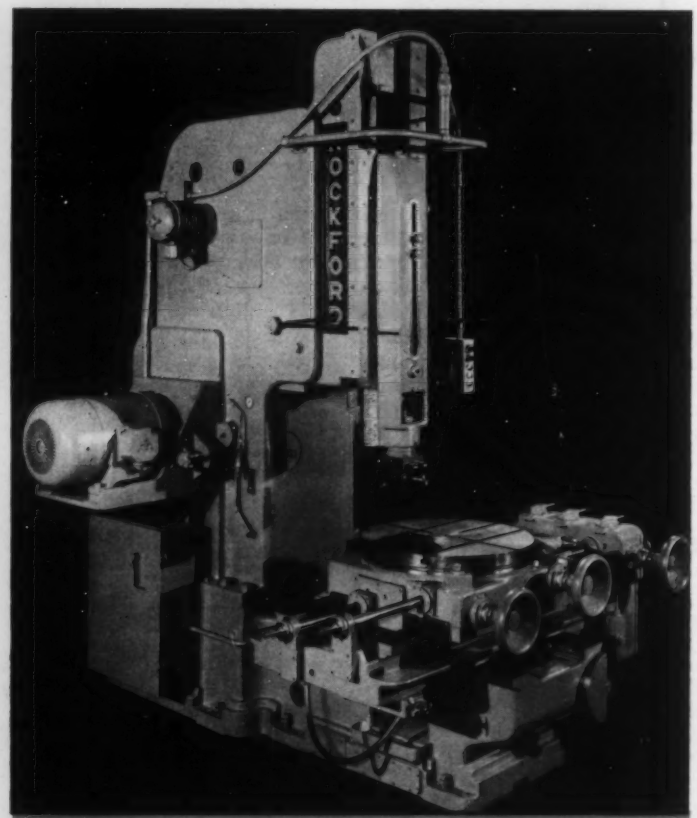

Markings of desired radius placed over lines. Mark with pricker through eyelet
1 in.
1/16 -in. thick clear plastic, 1 in. wide, 2 required. Join with eyelet permitting free movement.
Eyelet
1 in.
1 in.
2 in.
Hole in eyelet for pointer
Graduations and length as desired

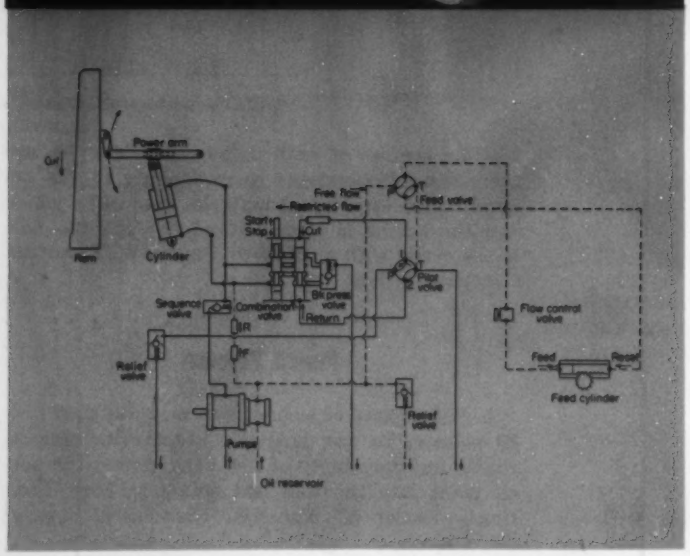
locating centers of radii to join two lines. To use the device, graduations corresponding to the desired radius are aligned with the lines to be joined and the center is then marked through the hole in the eyelet with a pointer.—JOSEPH W. YATCHUM, *Canonsburg, Pa.*

Pencil Pointer

A folded piece of emery cloth makes a good pencil pointer. To use, hold the folded cloth between thumb and forefinger of one hand. Insert the pencil point into the fold and rotate in both directions.—LAXMI K. NAGAICH, *Continental Tooling Co., Dayton, O.*

Slotting Machine—
Hydraulic-Mechanical Linkage Drives Ram





RAM drive of a recently introduced slotting machine combines a hydraulic cylinder and a mechanical linkage. This combination efficiently produces the required reciprocating motion while permitting quick, easy ram speed variation and simple adjustment of ram angle. Made by Rockford Machine Tool Co., the machine has a 36-in. maximum stroke. Top cutting speed is 100 fpm. Hydraulics are also used in the feed mechanism.

Ram speed control from 100 down to 40 fpm is provided by an electric motor which positions the cylinder piston rod connection at any desired point along the power arm. This arrangement has a constant horsepower characteristic since force exerted on the ram decreases because of the change in lever arm length as speed increases. Automatic stroke reversal is provided by the pilot valve which is operated by the ram at either end of its stroke to move the reversing spool of the combination valve and thus reverse cylinder stroke. A combination pump is used to supply power for both cutting and feeding. A flow control, or throttling, valve is incorporated in the circuit to permit feed adjustment.

Thermal Expansion of Materials

MACHINE DESIGN
Data Sheet

By V. H. Hayes, *Machine Designer*
Remington Rand Univac Div.
Sperry Rand Corp., St. Paul

CONSIDERABLE design time is usually required to find tables of coefficients of linear expansion. Then, too, the materials are usually listed in the tables alphabetically. Unfortunately, such alphabetical presentations do not lend themselves readily to design problems in which a specific permissible range of thermal-expansion values are given or are required.

To facilitate locating desired coefficients, the table presented here lists coefficients of thermal linear expansion of 108 materials in order of increasing values. Actually two values are given for each material. The first gives the linear expansion in millionths of an inch per inch per degree F. The second value, which is 300 times larger than the first, is the change in linear dimension in thousandths of an inch for a 10-in. length of material subjected to a 30 F temperature change. Both values most accurately apply in the 70 to 100 F temperature range.

Example: The larger number given in this table for each material brings the expansion value to a level that in most design situations can be better appreciated in terms of an appreciable percentage of sizes and drawing dimensions encountered. For example, steel has an expansion coefficient of 6.36 millionths of an inch per inch per degree F. This value is difficult to visualize or appreciate, but when multiplied by 300 it is approximately 0.002-in. (the table here gives 0.0019-in.). Such a dimension comes into a familiar range for design engineers.

Thermal Linear Expansion of Materials

Material	Coefficient of Linear Expansion (0.000001-in./in./-deg F) For 70 to 100 F range	Coefficient of Linear Expansion (0.001-in./-10 in./30 deg F) For 70 to 100 F range
Glass, fused quartz	0.32	0.096
Invar	0.44	0.132
Carbon	0.67	0.201
Diamond	0.70	0.21
Boron	1.10	0.33
Glass, Pyrex	1.80	0.54
Wood, pine (perpendicular to fiber)	1.90	0.57
Wood, Fir (parallel to fiber)	2.10	0.63
Arsenic	2.14	0.64
Tungsten	2.20	0.66
Porcelain	2.30	0.69
Masonry	2.50	0.75
Wood, maple (perpendicular to fiber)	2.70	0.81
Wood, oak (parallel to fiber)	2.70	0.81
Sapphire, synthetic (perpendicular to axis)	2.83	0.85
Quartz, natural (perpendicular to axis)	2.90	0.87
Silicon	3.00	0.90
Wood, pine (parallel to fiber)	3.00	0.90
Wood, oak (perpendicular to fiber)	3.00	0.90
Coke	3.00	0.90
Molybdenum	3.05	0.91
Brick	3.10	0.93
Osmium	3.17	0.95
Wood, fir (perpendicular to fiber)	3.20	0.96
Sapphire (parallel to axis)	3.22	0.96
Tungsten carbide	3.30	0.99
Chromium	3.40	1.02
Zirconium	3.50	1.05
Iridium	3.56	1.07
Tantalum	3.60	1.08
Wood, maple (parallel to fiber)	3.60	1.08
Carborundum	3.63	1.09
Titanium	3.96	1.19
Columbium (niobium)	4.00	1.20
Graphite	4.40	1.32
Quartz, natural (parallel to axis)	4.40	1.32
Marble	4.50	1.35
Rhodium	4.50	1.35
Glass, window	4.70	1.41
Platinum	4.79	1.44
Alundum	4.85	1.45
Granite	5.00	1.50
Glass	5.00	1.50
Sandstone	5.50	1.50
Iron, cast	5.56	1.67
Slate	5.80	1.74
Cement, neat	6.00	1.80
Epoxy glass-fiber laminate	6.00	1.80
Antimony	6.27	1.88
Steel	6.36	1.90
Palladium	6.41	1.92
Iron, wrought	6.48	1.94
Beryllium	6.80	2.04
Nickel	6.95	2.09
Cobalt	7.00	2.10
Monel	7.77	2.33
Gold	7.86	2.36
Concrete	8.00	2.40
Stellite	8.56	2.56
Copper	8.87	2.66
Aluminum bronze	9.16	2.75
Plaster	9.20	2.76
Tellurium	9.30	2.79
Beryllium copper, No. 25	9.30	2.79
Phosphor bronze	9.40	2.82
Brass	9.57	2.87
Bismuth	9.75	2.92
Bronze	9.86	2.96
Mercury	10.00	3.00
Stainless steel, 18-8, Type 302	10.00	3.00
Nickel silver	10.20	3.03
German silver	10.20	3.03
Barium	10.50	3.15
Silver	10.79	3.24
Type metal	10.80	3.24
Tin	11.63	3.49
Bakelite	12.20	3.66
Calcium	12.20	3.66
Aluminum	12.34	3.70
Manganese	12.80	3.84
Solder	13.88	4.17
Magnesium	14.30	4.29
Zinc	14.70	4.41
Mylar (polyester film)	15.00	4.50
Lead	15.71	4.72
Cadmium	16.60	4.98
Indium	18.33	5.50
Phenolic paper-fiber laminate	19.0	5.7
Selenium	20.0	6.0
Melamine, molding	23.0	6.9
Urea, molding	25.0	7.5
Ice	28.3	8.5
Sodium	30.0	9.0
Sulphur	37.5	11.3
Rubber, hard (Vulcanite)	40.0	12.0
Rubber	42.8	12.7
Potassium	46	13.8
Rubber, hard (Ebonite)	47	14
Phosphorus	69	21
Vinyl	70	21
Paraffin (61 to 100 deg F)	72	22
Polystyrene	80	24
Gutta percha	88	27
Plexiglas (acrylic plastic)	90	27
Nylon, molding	100	30
Polyethylene	100	30
Cellulose acetate	160	48
Ethyl cellulose	200	60

Standard types and characteristics of

Power Transmission Chain

POPULARITY of chain as a driving medium continues to grow for several reasons. Chain drives:

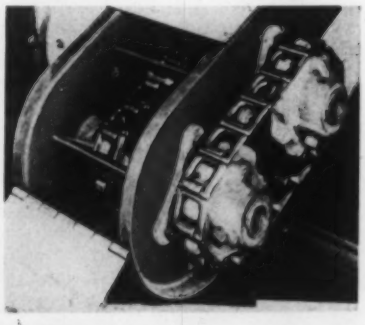
1. Have relatively unrestricted shaft center distances.
2. Are easily assembled.
3. Are normally elastic in tension.
4. Do not slip or creep.
5. Can be made compact.
6. Can be made to operate in high temperatures.
7. Do not deteriorate with age nor are they affected by sun, oil or grease.
8. Are available for a wide combination of speeds and loads.

Malleable Detachable Chain: Malleable detachable chain, as covered by American Standard B29.7-1954, is made in a range of sizes from 0.902 to 4.063-in. pitch, and average ultimate strength of from 700 to 17,000 lb, Fig. 1. These chains are generally recommended for use at speeds to approximately 350 fpm and loads to approximately 25 hp. The various parts of the malleable detachable link are referred to as the bar end and the hook end. The hook end or open end of one link couples with the bar end of the next link to form a chain.

Steel Detachable Chain: A similar chain is steel detachable chain covered by American Standard B29.6-1954, which is made in a range of sizes from 0.534 to just under 3-in. pitch and having average ultimate strengths of from 200 to approximately 5000 lb, Fig. 2. This chain is mainly used on farm machinery for speeds up to approximately 350 fpm and loads to approximately 25 hp. Steel detachable chain is designed with a hook end and a bar end for the same reason as are the malleable detachable links.

Pintle Chain: For slightly higher speeds, to about 450 fpm, and heavier loads, a group of chains known as pintle chains are available, Fig. 3. Pintle chains are assemblies of individual cast links having a full round barrel end cast integral with offset sidebars. These links are intercoupled with steel pins; hence, the ends of the pintle chain links are referred to as the barrel end and the open end of the links. Many of these chains have been designed to operate over sprockets for malleable or steel detachable chain; therefore, in this group are chains from just over 1 to 6-in. pitch and having average ultimate strengths of 3600 to 30,000 lb.

Typical applications of these chains are for drives in the lumber industry or as drive chains on



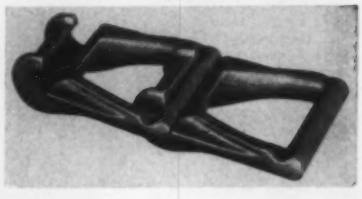


Fig. 1—Malleable detachable chain and typical application in a small, slow-speed drive on a grain elevator.

By B. L. Pearce

Chief Engineer
Ewart Plant
Link-Belt Co.
Indianapolis, Ind.

traveling water screens or drive chains around sewage treatment plants.

Steel Offset-Sidebar Chain: Steel offset-sidebar transmission chains, Fig. 4, are used extensively as drive chains on construction machinery, and there are applications of these chains operating at speeds up to 1000 fpm, transmitting loads to approximately 250 hp. In the assembly of offset-sidebar roller chain, manufacturers use in each link two offset sidebars, one bushing, one roller, one pin and, if detachable chain is supplied, a cotter of one type or another. Some chains of this general type have been manufactured without rollers.

Roller Chain: A very popular item is transmission roller chain, Fig. 5, as covered by ASA B29.1-1950. This chain has been and is being used for a wide variety of applications in many industries, Fig. 6, for it is available in pitches from ¼ through 3 in., and in the single-width type has average ultimate strengths of from approximately 925 to 130,000 lb. Transmission roller chains ASA B29.1 are assembled from roller links and connecting or rivet links. Each roller link consists of two link plates, two bushings and two rollers, while the connecting or rivet links are assembled from two plates of different dimensions than the link plates, two pins or rivets, and if detachable chain is used, two cotters.

These strengths are increased by using multiple-width chain of the basic design of the single-width chain, Fig. 7.

Double-Pitch Chain: In 1954, American Standard B29.3 was published covering a series of double-pitch power transmission chains, which are basically the same as ASA B29.1 transmission roller chains other than being twice the pitch, Fig. 8. Transmission roller chain ASA B29.1 and double-pitch power transmission chains ASA B29.3 have the same diameter pins and rollers, same width of rollers and same thickness link plates. The increased pitch is accomplished by eliminating every other joint part in the

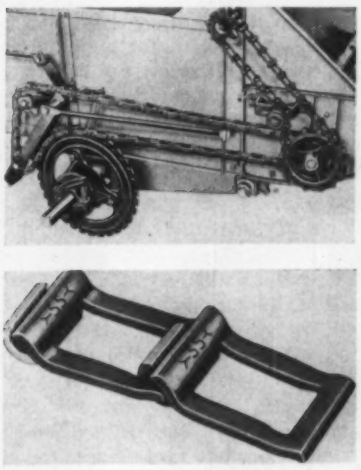


Fig. 2—Steel detachable chain and application on a manure spreader.

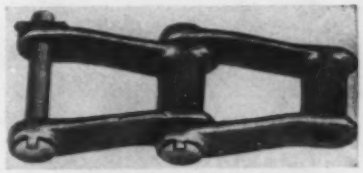


Fig. 3—Pintle chain for slightly higher speeds and heavier loads.

ASA B29.1 chain. Thus a ½-in. pitch ASA B29.1 chain becomes a 1-in. pitch ASA B29.3 chain. The double-pitch power transmission roller chains are primarily for slower applications than are the ASA B29.1 transmission roller chains.

Inverted-Tooth Silent Chain: Inverted-tooth silent chains, Fig. 9, are covered by ASA B29.2-1950. These are high-speed chains and are used predominantly for power take-off drives, as well as on power cranes and shovels. Inverted-tooth silent chains are assembled from a series of tooth links alternately assembled either

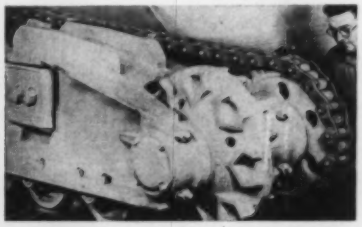


Fig. 4—Steel offset-sidebar transmission chain and illustration of its use in a crawler drive. These chains are also widely used as crowd and retract chains on cranes and shovels.

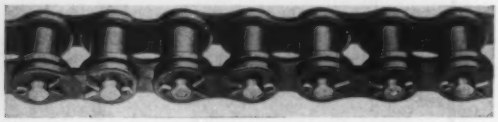
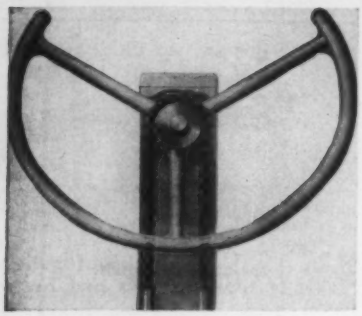
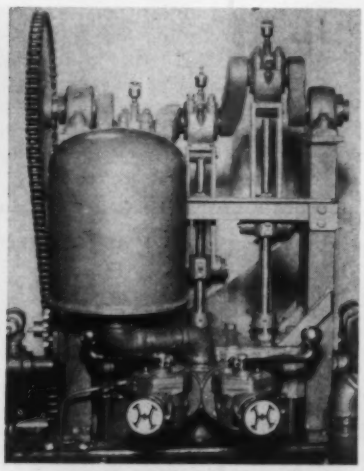


Fig. 5—Transmission roller chain.





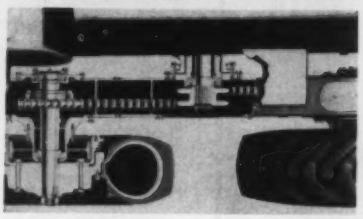


Fig. 6—Typical applications for transmission roller chain include drive for a hose reel on an oil truck, top left, fire-engine pump drive, top right, tandem drive on a road grader, bottom right, and linkage in control column of an airplane, bottom left.

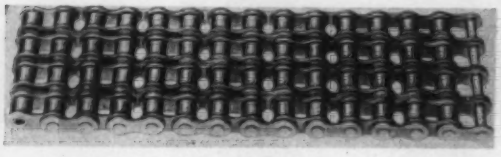


Fig. 7 — Multiple-width roller chain of same basic design as single-width chain.

with pins or a combination of joint components in such a way that the joint articulates between adjoining pitches. Center-guide chain has guide links which engage a groove or grooves in the sprocket, while side-guide chain has guides which engage the sides of the sprocket.

Chain Characteristics: All of these chains have certain similar characteristics. They have points of articulation or joints so that the chains can operate around sprockets, and they have link plates or sidebars of one type or another connecting the joint parts.

The pitch of a chain is that dimension from the center of one articulating point in the chain to the center of the next articulating point.

Transmission chains are generally selected for most jobs so that when the joints of the chains wear to such an extent that the chain starts to jump over the teeth of the sprockets, the chain itself is worn out before any of the chain members break. There are applications of transmission chains which are exceptions to this general rule; however, it is on the basis of this rule that the horsepower ratings for transmission chains in the existing ASA standards are established. Wear life of a chain has been found to be a result of what is commonly referred to as the projected bearing area of a chain and the working load imposed on the chain. Projected bearing area means length of the bushing of the chain multiplied by diameter of the pin in the chain, Fig. 10. As this projected bearing area is increased and the working load on the chain decreased, the life of the chain is considerably increased. A small projected bearing area and a heavy load shortens chain life.

There are applications which are exceptions to this method of chain selection, and it is here that fatigue life of a chain comes up for consideration. A simple definition of the fatigue life of a chain is the number of load impulses of a specific magnitude that a chain can absorb before one of its members breaks.

Although the search continues for a chain having a maximum ultimate strength, maximum wear life and maximum fatigue life from the least costly of materials, no one type of chain has been designed yet that will accomplish to the best advantage the jobs that all seven of the chains covered here will do individually.

Chain Materials: Malleable detachable chains are cast from malleable iron. Steel detachable chains are manufactured from medium-carbon nonalloy steel strip and then hardened to provide wear and strength to the chain joint. At times, low-alloy steels have been used, but such chains are unusual.

With respect to materials used in the manufacture of transmission roller chain ASA B29.1, offset-sidebar roller chain, and inverted-tooth silent chain ASA B29.2, there seem to be varied opinions as to what materials are needed to provide successfully operating chains, and chains manufactured by different companies of different materials are today operating successfully. The pins in these chains must have the quality of hardness and hardness depth to provide acceptable joint wear, and furthermore, they must have high shear strength so that the chains in which they are used will provide sufficient ultimate strength. To meet this combina-

Fig. 8 — Double-pitch power transmission chain and typical application on a lower-speed drive.

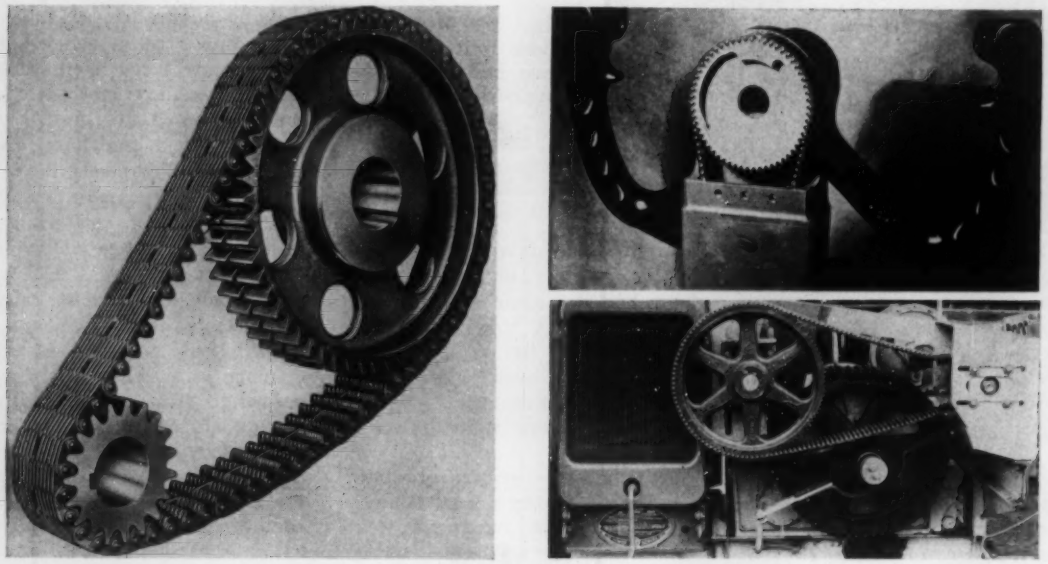


Fig. 9—Inverted-tooth silent chain and applications in a control column and in an Air Force ground handling winch. A multiple-width roller chain is also used in the winch.

tion of conditions, some manufacturers use a low-carbon alloy steel which is casehardened for high surface hardness and tempered for core strength. The degree of alloy used in the various sizes is determined by the diameter of the stock used, and this is made necessary by the hardening and quenching problem. Some manufacturers feel that for certain of the broad group of chains discussed here, high-carbon heat-treated pins do the job better than casehardened pins, so the job expected of the particular group of chains involved determines the material from which the parts are manufactured.

Bushings are subject to wear and roller impact, and therefore, are mostly manufactured from low-carbon steels, casehardened and properly tempered for resistance and toughness.

Rollers are subject to wear and sprocket impact, and therefore are generally made from alloy steels, casehardened to provide a hard surface and a tough core for impact. Here also there is a school of thought that feels that high-carbon steel heat-treated rollers are better for certain applications.

Link plates or sidebars are the tension members of the chain and are subject to repeated application of tensile load; therefore, they must be strong and tough. For this reason, medium-carbon alloy steels are heat-treated and used in most applications. However, some manufacturers find that in the thinner materials cold rolling often gives sufficient strength, and heat-treatment can be omitted.

From a paper entitled "Transmission Chain Standardization" presented before Engineer Research and Development Laboratories, Fort Belvoir, Va., November, 1956.

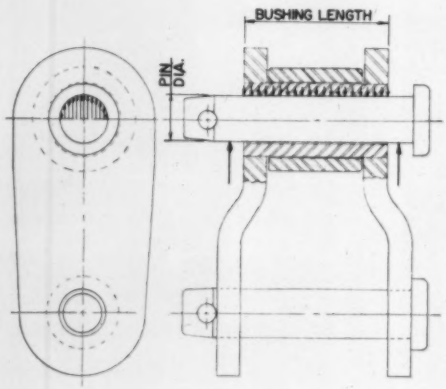


Fig. 10—Typical chain joint in which projected bearing area equals bushing length times pin diameter.

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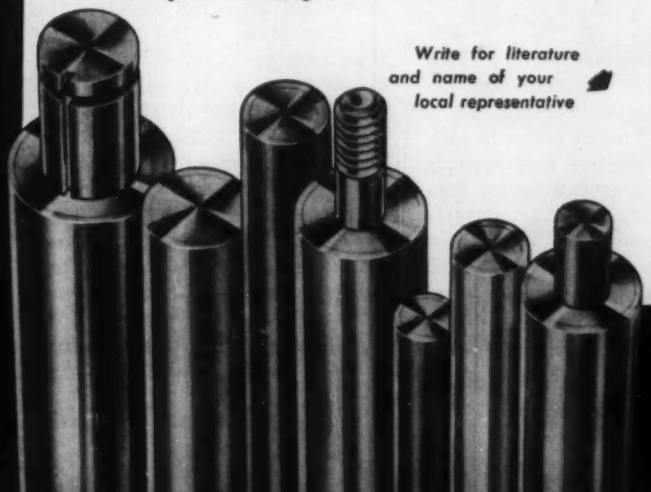

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Circle 454 on page 19

Reducing Noise

in motor driven equipment

By E. R. Cunningham and G. L. Wolfert

General Electric Co.
Fort Wayne, Ind.

METHODS for reducing the amount of vibration transmitted from a motor to associated equipment include:

1. Increasing the mass of the part of the motor to which forces are applied.
2. Adding a tuned vibration absorber to the motor or vibrating part.
3. Adding an inertial-friction vibration damper to the motor.
4. Using vibration isolation between the motor and the equipment.
5. Eliminating any vibration amplification caused by too low a stiffness of "rigid" type motor supports.

The possibility of reducing the amplitude of applied forces should not be overlooked. Changes in the electrical design of a motor to obtain modified two-phase operation with a run capacitor will reduce torque pulsation forces. However, the capacitor is usually more expensive and takes more space than isolation mountings, and the maximum reduction is limited.

Increased Mass: The possibility of increasing the mass of the motor is opposite to the basic trend in design which is making motors smaller and lighter, to obtain greater output per unit of cost. Increased mass is expensive and space consuming in relation to the improvement obtained. Vibration reduction obtained in this manner is proportional to ratio of masses, except for resonance effects.

Tuned Vibration Absorbers: A tuned vibration absorber is a device which opposes any vibration of the body to which it is attached. The tuned absorber is essentially a spring and a mass attached to the motor so that it is free to vibrate in the same direction as the motor for the vibration which is to be reduced. The natural frequency of this system is made the same as the frequency of the applied force, but the mass vibrates 180 deg out of phase, so that the applied force is opposed by an equal and opposite force and canceled out. Theory shows that the mass of the absorber is not important since generally the assumption is that the mass can attain an amplitude of vibration which allows its acceleration forces to equal the applied forces. However, practical springs have limiting stresses and must have a spring constant large enough to allow this force at stresses below the yield point. This value of spring constant dictates the size of the mass, since the resonant frequency is given.

The advantage of the well designed, tuned vibration absorber is that it eliminates practically all of the vibration of the body to which it is attached for a particular frequency.

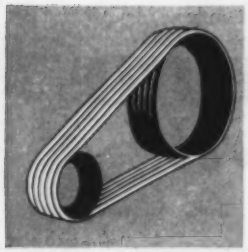
The disadvantages of the tuned absorber, relative to vibration isolation, are numerous. They are: space and material are required with resulting higher cost; long fatigue life is not easily obtained; the device must be tuned accurately to the applied force frequency; inherent damping must be low and resonant frequencies on both sides of the force frequency are created. Also, the absorber must be designed to withstand the peak vibration which it may have to counteract, or it may be damaged.

Inertial - Friction Vibration Damper. The inertial - friction vibration damper consists of a mass fastened to the motor in such a way that relative movement is possible but accompanied by frictional resistance which converts vibrational energy to heat. This device is in a class with the tuned absorber but is less versatile and suffers from a limited life due to possible wear, unless fluid friction is used. It requires and may lose adjustment, works only above a minimum value of the applied force, and is relatively expensive.

Vibration Isolation: The next method is vibration isolation, which consists of supporting the motor relative to the appliance with springs. Thus, the motor is allowed to vibrate in the direction of the applied force, permitting the inertia forces of the vibrating motor, as well as the supporting springs, to oppose the applied forces. As the freedom for vibration increases, the inertia forces increase, thus decreasing the transmitted vibration. Isolation involves the transfer of vibratory energy between the motor and the springs as opposed to the absorption of energy and conversion to heat involved in damping. The springs used to provide the freedom to vibrate are usually called isolation mountings.

Eliminating Vibration Amplification: Elimination of vibration amplification is distinguished from vibration isolation in that vibration isolation reduces the transmissibility below 1 (the transmissibility for a rigid mounting), whereas reduction of vibration amplification reduces the transmissibility to 1 from values appreciably greater than 1. This distinction is made because what appears to be a rigid mounting at first glance may actually be a mounting with sufficient compliance to provide an amplification of vibration over that of a rigid mounting, and in such cases stiffening of the mounting will provide an appreciable and possibly sufficient reduction in transmitted vibration. Attainment of a rigid mounting increases the effective mass of the motor and thus reduces vibration by the increase in mass obtained. In general, however, a truly rigid mounting system is difficult to attain since the equipment itself must be considered a series of spring-coupled masses.

From a paper entitled "Some Problems and Design Factors Concerning Noise in Motor Driven Home Appliances" presented at the AIEE Winter General Meeting in New York, January, 1957.



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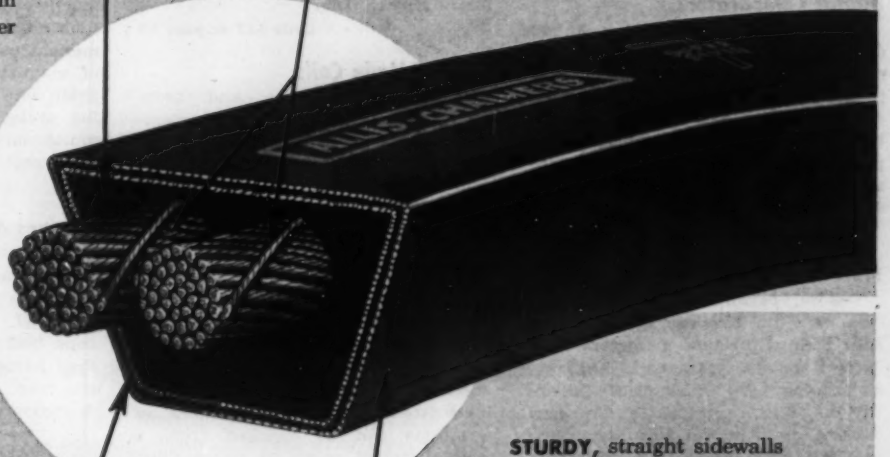

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HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Remote Reading Gages

Truscale remote reading water level gages with scale inclined up or down is subject of data sheet 291. Warning devices are described. 1 page. Jerguson Gage & Valve Co.

Circle 651 on page 19

Switches & Relays

Forty different switches and relays, ranging from standard to miniature size, for use in electrical and electronic equipment are described in illustrated catalog. Specifications, capacities, dimensions and other design considerations are discussed. 12 pages. Jaidinger Mfg. Co.

Circle 652 on page 19

Digital Comparators

Typical applications of packaged digital comparators for control or operation in aircraft, machine tools, production equipment, navigation, radar and processes are suggested in bulletin 418. This transistorized, printed circuit unit offers immediate solution to digital servo problems. 4 pages. Norden-Ketay Corp.

Circle 653 on page 19

Flareless Tube Fittings

Design, performance and application data on flareless type Ferulok tube fittings for tube diameters from ⅛ to 2 in. are contained in illustrated catalog 4320. Also discussed are fittings for mounting in the new SAE straight-thread boss and utilizing an O-ring for sealing. 28 pages. Parker Appliance Co., Tube & Hose Fittings Div.

Circle 654 on page 19

Hydraulic Power Pumps

Type HG constant displacement pumps are rated 3 to 10 hp with deliveries of 1 to 5 gpm at continuous operating pressures of 3000 and 5000 psi. Full specifications of these hydraulic power pumps are given in bulletin 46601-B. 4 pages. Oilgear Co.

Circle 655 on page 19

Packaged Controls

Among the low cost packaged controls described in bulletin 571 are rectifier and filter, safe-start network, cycle sequence control, pulse-forming network, function relays, counters, interlocks and static switching systems. Directors and Sensors solve control problems. 4 pages. Sensory Inc.

Circle 656 on page 19

Aircraft Switches

Over 140 different switches, including phenolic cased, small metal-covered hermetically-sealed and high temperature types, are subject of catalog 78. Entitled "Basic Switches for Airborne Equipment," guidebook tabulates electrical data and operating characteristics. 32 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 657 on page 19

Custom-Made Coils

Production facilities and techniques employed in making custom-made industrial coils are detailed in bulletin S-20. Various types of vacuum impregnated coils can be produced for wide range of electrical equipment. 8 pages. Stonite Coil Corp.

Circle 658 on page 19

Radiation Monitor

Remote area radiation monitoring systems, designed to meet the requirements of the AEC, are described in illustrated bulletin. A number of locations can be checked from a single control point. 4 pages. Victoreen Instrument Co.

Circle 659 on page 19

Slotted O-Rings

Advantages of Teflon slotted O-rings are outlined in data sheet. Installation data and specification for extensive line are given. 2 pages. Garlock Packing Co.

Circle 660 on page 19

General Purpose Pumps

Complete design and application data on model C general purpose, rotary, internal gear, positive displacement pumps are presented in bulletin 102. Capacities range from 2 to 200 gpm at pressures to 100 psi when operated at 1200 rpm. 12 pages. Tuthill Pump Co.

Circle 661 on page 19

Small Tubing

Data Memorandum No. 1 gives technical information on standard and special analyses available in seamless and Weldrawn small diameter tubing. Types covered include stainless, carbon and alloy steels; nickel and nickel alloys; copper and copper base alloys; glass-sealing alloys and reactive metals and alloys. 3 pages. Superior Tube Co.

Circle 662 on page 19

Tape Control System

Digimatic tape control system for machine tools is fully explained in illustrated technical bulletin. Numerical control through the medium of magnetic tape is utilized to program and execute complex machining cycles through the use of servo motors on the machine tool. 12 pages. Electronic Control Systems, Inc.

Circle 663 on page 19

Sheaves & Pins

Description of "tool steel" process sheaves and pins and their advantages are presented in illustrated bulletin 947. Sheaves create savings in rope, bushings and replacements. Surface hardened pins have tough, ductile core. 4 pages. Tool Steel Gear & Pinion Co.

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Differential Transformers

Infinite resolution, Teflon leads and epoxy potting are features of Minatron differential transformers, described on specification sheets. Units cover range of ±0.003-in. to ±3.000-in. Stocked unit will operate at 220° F, special units to 500° F. 2 pages. Minatron Corp.

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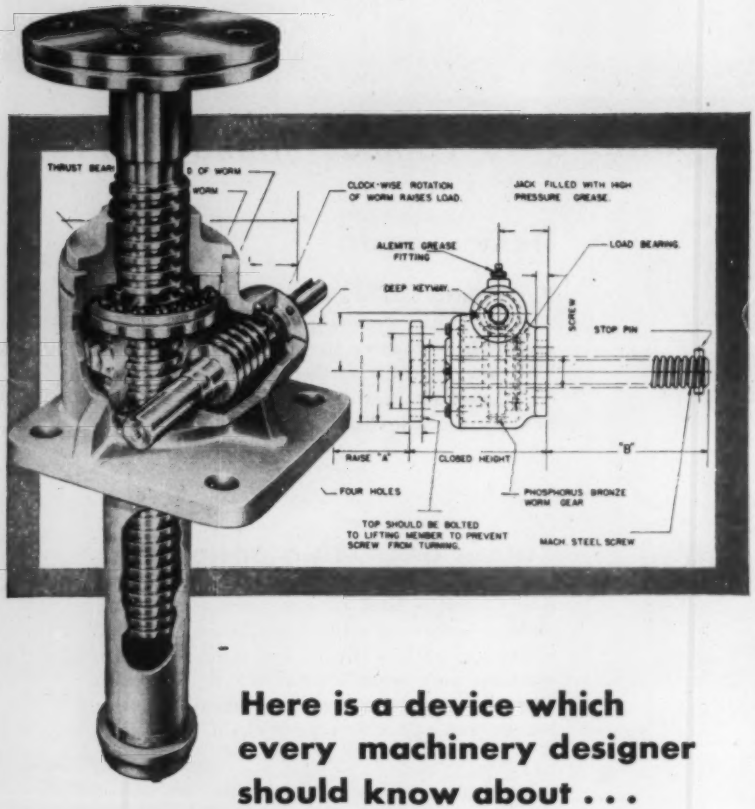

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Circle 457 on page 19

Helpful Literature

ings, currents, sizes and torque are covered. 4 pages. Merkle-Korff Gear Co., Flexo-Action Div.

Circle 666 on page 19

Automatic Controls

Automatic electric, electronic and pneumatic controls for variety of functions are described and illustrated in catalog 6f/MI. Covered are temperature, pressure, humidity and flame safeguard controls; motors, relays; dampers; operators; panels and cubicles. Specs are given. 12 pages. Minneapolis - Honeywell Regulator Co., Industrial Div.

Circle 667 on page 19

Flexible Disk Couplings

Various types of Thomas flexible disk, all metal couplings for power transmission are shown on data sheet 37-52. Single and two-bearing application types are covered. 2 pages. Thomas Flexible Coupling Co.

Circle 668 on page 19

Slip Ring Assemblies

Custom-built slip ring assemblies, brush holder assemblies, brush and leaf assemblies and contacts are subject of bulletin S-2056. General design data are included along with information on silver contact brush grades. 4 pages. Superior Carbon Products, Inc.

Circle 669 on page 19

Water-Sealed Splices

Sealink permanent, water-sealed and insulated wire splices are described in bulletin. They meet MIL-T-7929A and are installed to No. 26 to 10 wire sizes with simple hand Hytool. Dimensional data and test reports are included. Burndy Corp., Omaton Div.

Circle 670 on page 19

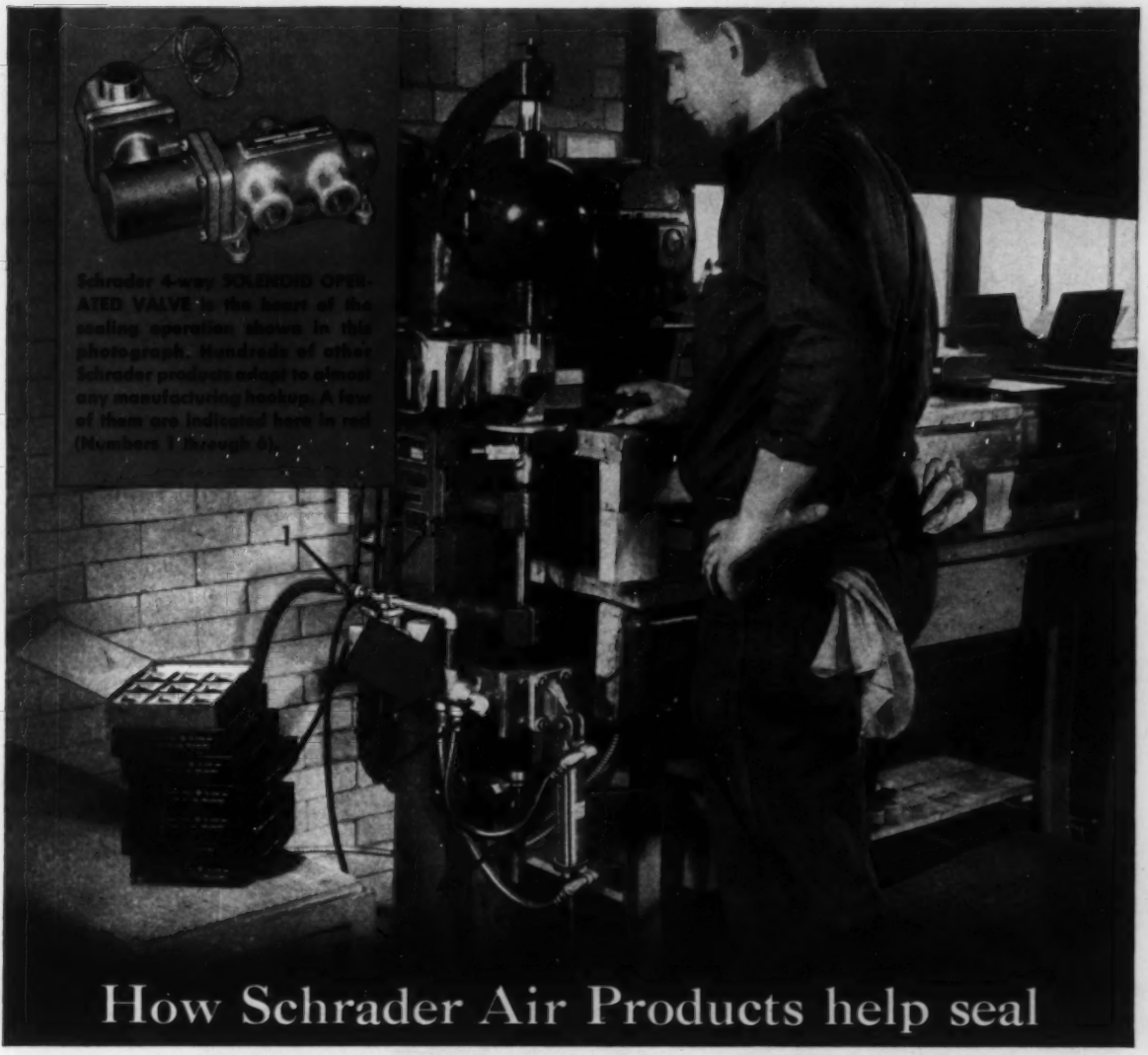
Variable Pitch Drives

Single-groove, wide range, variable pitch and companion sheaves for R and W wide range belts; variable pitch single-groove sheaves of locking ring type for Q and R wide range belts; and two-groove type for B and C standard cross section belts are described in detail and illustrated in catalog V-183-A. 12 pages. Browning Mfg. Co.

Circle 671 on page 19

Pushbuttons

How to select the correct pushbutton is purpose of catalog on oiltight and general purpose pushbuttons,


Schrader 4-way SOLENOID OPERATED VALVE is the heart of the sealing operation shown in this photograph. Hundreds of other Schrader products adapt to almost any manufacturing hookup. A few of them are indicated here in red (Numbers 1 through 6).

How Schrader Air Products help seal

5000 pellet boxes per day—3 times faster!

Box sealing is a common operation performed by compressed air. Just how speedy it can be is demonstrated at a New York arms manufacturing plant, where 5000 boxes of pellets are crimped tight each day. The back-breaking job of crimping by foot power is eliminated, and the operator does not become fatigued.

Wherever operations are automated—in holding or positioning work, moving scraps or chips, or synchronizing actions—air can help. By making these steps automatic, more efficient manufacturing is achieved.

In many cases this can be done more economically with Schrader Air Products than in any other way. Upon request, Schrader engineers will assist you in planning for the most efficient use of air and in selecting the products best suited to your applications. Outline your problem to us . . . we'll be glad to help you. Or, send for the latest informative booklets which show Schrader Air Products that will help you increase production—economically.

Schrader®
ESTABLISHED IN 1844

A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
472 Vanderbilt Avenue, Brooklyn 38, N. Y.

FIRST NAME IN THE USE OF AIR
FOR INDUSTRIAL PRODUCTION AND CONTROL

Circle 458 on page 19

New horizons in product design with...
NICKELOID
METALS
More Than a Metal—It's a Method
Beyond the design and production limits of ordinary metals rises Nickeloid Pre-Finished Metals, a versatile design material that transforms design ideas into product realities. Available in 14 finish-to-base metal combinations, this finished raw material opens wide new horizons in product design, adapts readily to standard production methods, inspires new products — new designs. Saves production time, costs and equipment investment, too, because it's PRE-finished.
NICKELOID METALS
SINCE 1898
NM
CHROME, NICKEL, COPPER AND BRASS FINISHES ON BASE METALS OF STEEL, ZINC, COPPER, BRASS OR ALUMINUM. SHEETS, STRIPS, COILS.
Get the Facts! Write for Free Sampler-Selector
AMERICAN NICKELOID CO.
Peru 8, Illinois

Helpful Literature

pilot lights and accessories. Included are descriptions of all units, dimensions, cam action and schematic diagrams. Specifications are given. 32 pages. Furnas Electric Co.

Circle 672 on page 19

Alloy Machinery Parts

Expanded booklet on machinery parts made of Haynes alloys includes data on chemical compositons, physical and mechanical properties, corrosion resistance and machining. Chapters cover cobalt base, nickel base and iron base alloys and applications falling into each group. Many parts are illustrated. Haynes Stellite Co.

Circle 673 on page 19

Glass Fiber Materials

Wide variety of Fiberglas materials for industry is illustrated and described in brochure PS 1-2. Products shown are used to control heat and sound, add strength, insulate electrical equipment, filter air and add beauty. 12 pages. Owens-Corning Fiberglas Corp.

Circle 674 on page 19

Electrical Design

"Trends and Development for Electrical Design Engineers" discusses permanent magnets, Thermistors and Thyrite varistors in relation to designer's problems. Booklet points out new approaches, possibilities and methods for using these products. 12 pages. General Electric Co., Metallurgical Products Dept.

Circle 675 on page 19

Packless Fluid Valve

Packless valves for applications involving hazardous liquids and gases, as well as uses in nuclear energy installations, are described in catalog F. Valves contain a metal bellows as the packless feature. 22 pages. Robertshaw-Fulton Controls Co., Fulton Sylphon Div.

Circle 676 on page 19

Wire Markers

A permanent method of coding wire with plastic tubular markers is described in bulletin. Markers can be bought by the box or in tubes. 1 page. E.C.P. Corp.

Circle 677 on page 19

Welded Steel Tubing

Bulletin P.O. 856 describes tubing formed from Zincgrip steel (zinc-coated), Aluminized steel (aluminum-coated), hot rolled steel and cold

Five cylinder series... each the best of its kind!

Here you see one more reason why experienced cylinder users prefer Hannifin cylinders...there is a Hannifin cylinder series for every type of service.

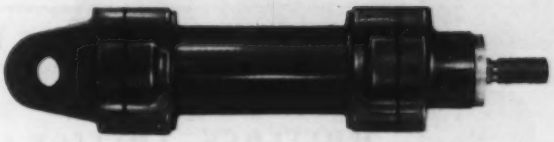
What pictures cannot show you is the extra effort that goes into every Hannifin cylinder, all the way from the drawing board to the shipping dock. This brings you design features other cylinders simply do not have...superior workmanship where it's most needed for long, trouble-free service...and better delivery promises, better kept. All at prices no higher than you may have been paying for less satisfactory cylinders.

There's a Hannifin man near you—or, if the need is urgent, call us long distance. He or we will welcome the opportunity to help you as you select the Hannifin cylinder series that best meets your needs.

AIR AND HYDRAULIC

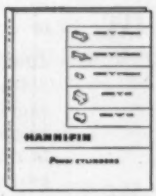
HANNIFIN

POWER CYLINDERS

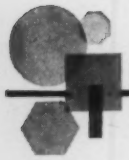


COMPLETE CYLINDER FILE

Write for your copy of this new Hannifin Cylinder File...complete, easy-to-use, easy-to-order-from information on five lines of Hannifin cylinders. Write Hannifin Corporation, 515 S. Wolf Road, Des Plaines, Illinois.



Circle 460 on page 19



WHEELOCK, LOVEJOY & COMPANY, INC.

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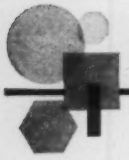

WHEELOCK, LOVEJOY & COMPANY, INC.

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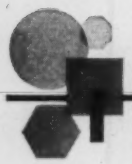
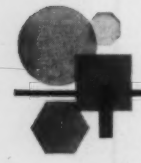


WHEELOCK, LOVEJOY & COMPANY, INC.

265 Pennsylvania Avenue, Hillside New Jersey



WHEELOCK, LOVEJOY & COMPANY, INC.

12989 Greeley Avenue, Detroit Michigan

7 WAREHOUSES AT YOUR SERVICE

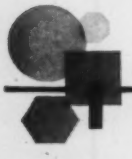
You'll get quick action on your order for alloy steel bars, billets or forgings . . . no matter what size, shape or heat treatment you require . . . when you call any one of our seven warehouses.

All seven are conveniently located in principal industrial areas. Each is staffed by expert metallurgists, and is well-stocked to give you speedy service.

Fill your current needs by ordering our own HY-TEN steels, the "standard steels of tomorrow", or standard AISI or SAE grades.

Or write today to our Cambridge office for your *free* Wheelock, Lovejoy Data Sheets. They contain complete technical information on grades, applications, physical properties, tests, heat treating, etc.

In Canada: Sanderson - Newbould, Ltd., Montreal and Toronto



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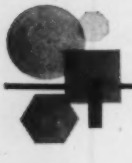
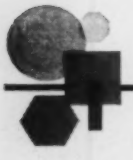
144 Milton Street, Buffalo New York



WHEELOCK, LOVEJOY & COMPANY, INC.

4524 W. Mitchell Avenue, Cincinnati Ohio



HOME OFFICE:

WHEELOCK, LOVEJOY & COMPANY, INC.

133 Sidney Street, Cambridge 39 Massachusetts

Helpful Literature

rolled steel. Pressure tested tubing and fabricated parts are also included. Sections cover mechanical properties and fabrication. 16 pages. Armco Steel Corp.

Circle 678 on page 19

Generator Control Panels

Generator control panels in floor mounted, wall mounted and generator mounted models are subject of bulletin PAN.1156. Panels are made for Kato line of generators which includes 60-cycle units up to 400 kw and 400-cycle units up to 200 kw. 2 pages. Kato Engineering Co.

Circle 679 on page 19

Permanent Ceramic Magnets

Indox V high energy ceramic permanent magnets are showing promise in direct current motor, drive, loudspeaker, periodic focusing, separator and chucking applications. Bulletin 16 gives data on this material and pictures standard sizes. 2 pages. Indiana Steel Products Co.

Circle 680 on page 19

Motor Speed Control

Servospeed motor control in either manual or automatic control models provides operation of special ball-bearing direct current motors from an alternating current power source. Units allow remote stepless adjustment of speed over ranges greater than 20:1. Brochure describes these 1/50 to 3-hp units. 8 pages. Electro Devices Inc.

Circle 681 on page 19

Recording Oscillograph

Type 5-119 recording oscillograph described in bulletin 1536B will provide direct graphical presentation of large quantities of data, simultaneously and with positive time correlation, under extreme environmental conditions. Price lists are included. 12 pages. Consolidated Electrodynamics Corp.

Circle 682 on page 19

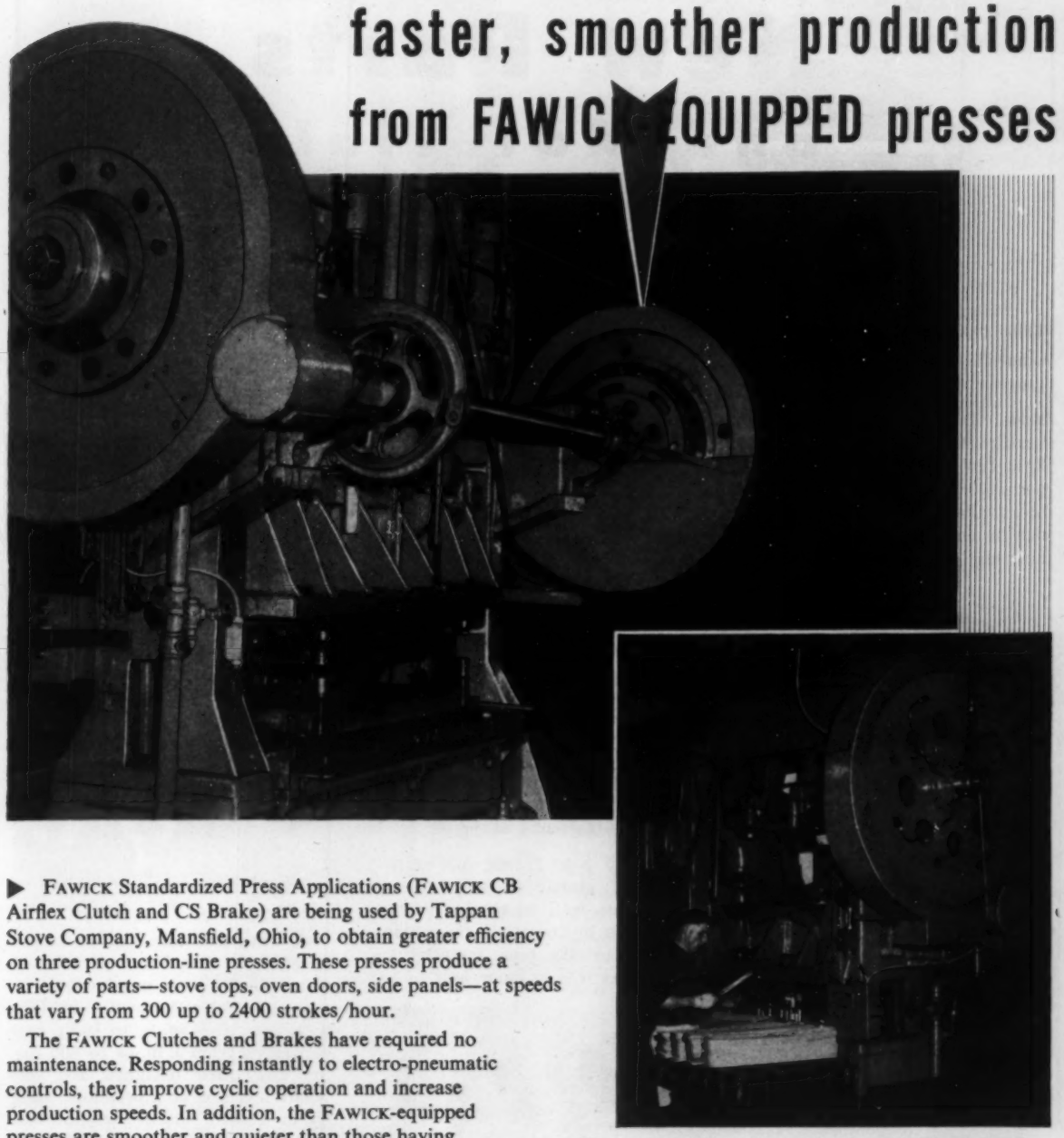
Low-Tension Ignition

How low-tension ignition can improve performance in large gasoline engines of 1, 2, 4, 6 and 8 cylinders is related in bulletin FM238A. Three basic methods of controlling the primary current pulse in order to give desirable firing characteristic are schematically shown. 4 pages. Fairbanks, Morse & Co., Magneto Div.

Circle 683 on page 19

AT TAPPAN STOVE COMPANY...

faster, smoother production from FAWICK EQUIPPED presses



▶ FAWICK Standardized Press Applications (FAWICK CB Airflex Clutch and CS Brake) are being used by Tappan Stove Company, Mansfield, Ohio, to obtain greater efficiency on three production-line presses. These presses produce a variety of parts—stove tops, oven doors, side panels—at speeds that vary from 300 up to 2400 strokes/hour.

The FAWICK Clutches and Brakes have required no maintenance. Responding instantly to electro-pneumatic controls, they improve cyclic operation and increase production speeds. In addition, the FAWICK-equipped presses are smoother and quieter than those having a mechanical clutch and brake.

The performance and productivity of all O.B.I. presses, new or old, can be improved with FAWICK Standardized Press Applications. For more information, ask your nearest FAWICK Representative or the Home Office for Bulletin ML-172.

FSPA-modernized presses at Tappan Stove Company include both back-shaft geared presses and a straight-side press with clutch and brake crankshaft-mounted. Fawick components—CB Airflex Clutch, CS Brake, Timing Rotorseal, High-Speed Clutch Controls—have improved performance and cut maintenance of these high-production presses.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
In Canada: Fawick Canada, Ltd., Toronto

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

Circle 462 on page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Hydraulic Pumps

handle fluid pressures to 3000 psi

Model OB pumps are designed to handle lubricating hydraulic and light fuel oils at pressures to 3000 psi and speeds to 1800 rpm. They are available as standard units or can be engineered into existing or new equipment. Modified versions

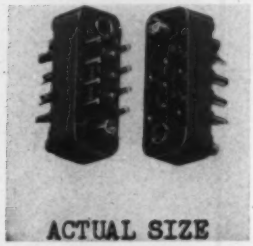
with special gearing are available where speeds up to 3600 rpm are needed. Pumping capacity is 24, 30 or 39 gph in either right or left-rotation types. Two-bolt integral mounting or bracket-type mounting may be used. **Sundstrand Machine Tool Co.**, Hydraulic Div., 2210 Harrison Ave., Rockford, Ill.

Circle 684 on page 19

Miniature Connector

precision unit has up to 34 contacts

Series 22 precision continental connector is for aircraft and instrumentation applications. Polarization is positive with a reversed guide pin and stainless-steel guide socket. Floating contacts insure positive self-alignment of each contact. Phosphor-bronze contacts are gold plated over silver for low contact resistance and soldering ease. Connector is available with 7 to 34 contacts, with or without aluminum hoods. The 11-contact connector (shown) is 0.78-in. long and 0.27-in. wide. Mounting dimension (center-to-center on



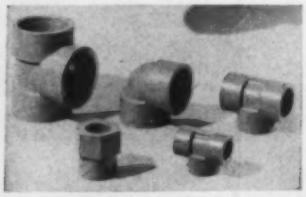
mounting studs) is 0.532-in. **DeJur-Amsco Corp.**, Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 685 on page 19

Plastic Pipe Fitting

eliminates leaks at joints

Uscoweld pipe fitting has a thin layer of plastic on a section of the inside wall to eliminate leaks at joints in cemented or solvent-welded plastic pipe installations. The layer makes inner half of the



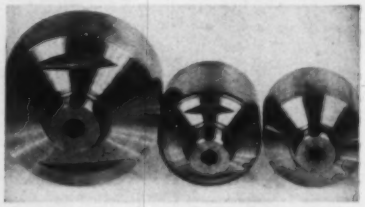
fitting slightly smaller than the OD of the pipe it is used to join. Light coat of solvent base cement on the inside of the fitting and on the pipe end softens plastic layer so the pipe can be pushed snugly into place. High contact pressure between pipe and fitting causes a positive weld. Fitting also has a flared entrance, leading to the narrow interior section, so pipe can be inserted quickly and easily. Flared opening also aligns pipe automatically for welding. Fitting is a tough, lightweight styrene-acrylonitrile blend with good corrosion resistance. It is available for standard size pipe from ½ to 2 in. diam. **United States Rubber Co.**, Mechanical Goods Div., Ft. Wayne, Ind.

Circle 686 on page 19

Miniature Clutches

maintain torque output indefinitely

Miniature instrument slip clutches are of three types: Magnetic, spring beam, and multiple friction



disk. They maintain a given torque output for indefinite periods of time. Units are constructed in five sizes from ¾ to 2¼ in. OD, with bore sizes of ⅛ to ½-in. and capacities from 1 in.-oz to 800 in.-lb. They are designed for use where space is at a premium, such as in guided missiles, computers, tracking devices, film rewinders, storage devices, memory devices and business machines. **Radial Metal Products Inc.**, 1044 Linwood St., Brooklyn 8, N. Y.

Circle 687 on page 19

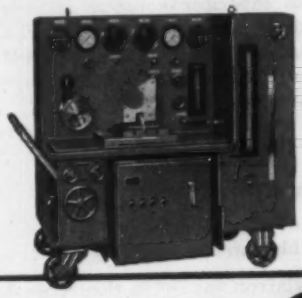
Nuclear Power Packs

deliver high energy and have life of over 25 years

Miniature nuclear power packs operate over wide ranges of temperature, acceleration and vibra-

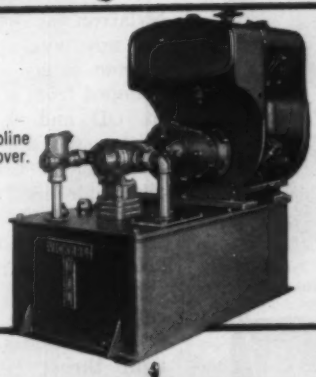
Pulpit type power unit provides full visibility, easy accessibility.

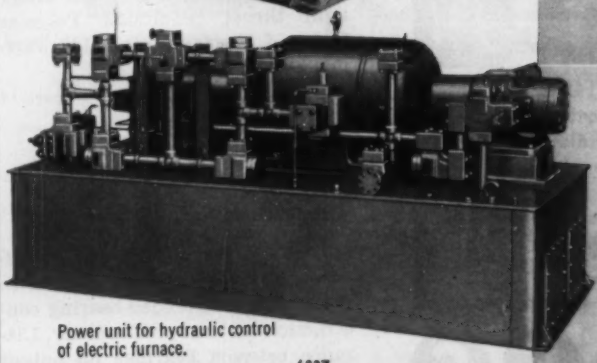
Compact power unit showing gasket-mounted valves.



Portable power unit for testing pumps.

Power unit with gasoline engine as prime mover.





Power unit for hydraulic control of electric furnace.

6837

Individually Designed to Meet *SPECIFIC* Needs

VICKERS®

Custom Built

HYDRAULIC POWER UNITS

DEPENDABLE PERFORMANCE

IMPROVE AND SIMPLIFY DESIGN

REDUCE INSTALLATION COST AND TIME

EASIER SERVICING

BETTER APPEARANCE

Vickers engineers approach the design of a custom-built hydraulic power unit from the standpoint of the customer's INDIVIDUAL needs. The sole objective is to meet HIS requirements with the best hydraulic "package". This assures the most compact, efficient and convenient hydraulic equipment for the particular machine.

A Vickers Hydraulic Power Unit includes all necessary pumps, valves, intermediate piping, oil reservoir, motors, controls, etc., as well as all hydraulic accessories (oil filters, air cleaners, oil level gauges, fittings, etc.). Hydraulic connections can be grouped in a convenient manifold.

In addition to the advantages mentioned above, each Unit is pretested at the factory and ready for immediate operation. Vickers undivided responsibility for the entire hydraulic control system is also an important feature to both the machine builder and his customer. Write for Bulletin 52-45.

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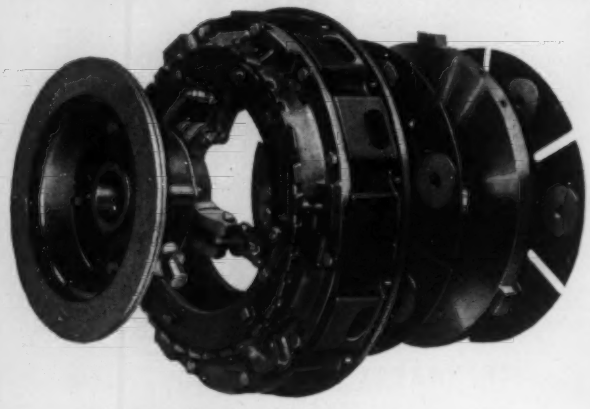
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

ROCKFORD

Double Plate Clutch Provides More Torque



- With Less Size

Used in a large crawler-type tractor, this Double-Plate ROCKFORD Morlife CLUTCH (Utilizing two MORLIFE® plates—equipped with button type facings) provides 100% more torque capacity than previous clutches of same diameter.

400% more service life and 50% more heat resistance are other features of this Heavy-Duty ROCKFORD Morlife CLUTCH.

A brake plate is mounted on the heavy-duty, ball bearing type release sleeve.

If you have a heavy-duty vehicle in the planning stage, it will pay you to learn about these and other advantages of this new clutch—before you design the drive line. A design study of your present drive lines might indicate advantages of using this ROCKFORD CLUTCH. For information write Department D — or

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ENGINEERING B-W PRODUCTION

CLUTCHES

New Parts

tion, and have a shelf and use life of over 25 years. They are suitable for use in weapon and ordnance systems as power sources for warheads, fuzes, destructors, timers and programming devices. Capable

of delivering energy pulses up to 337,000 ergs, the power packs range in size from 1 to 2 cu in. Pulse energy can be used repeatedly, and means are provided to regulate capacitor voltages at specific values between 75 and 750 v. **Universal Winding Co.,** Patterson Moos Div., 90-28 Van Wyck Expressway, Jamaica 18, N. Y.

Circle 688 on page 19

Thrust Washers

of filled nylon have high wear resistance

Nylatron GS nylon thrust washers are now available from stock in a wide range of sizes. They are stamped from strip to ⅜ to 1 5/16 in. OD and ⅛ to 1 in. ID in thicknesses of 1/64, 1/32 and 1/16-in. Washers are of molybdenum disulphide-filled nylon formulation which has good dimensional stability, low deformation under load, low coefficient of friction and high wear resistance. Applications include use where good wear resistance is required under light thrust conditions. **Polymer Corp. of Pennsylvania,** 2140 Fairmont Ave., Reading, Pa.

Circle 689 on page 19

Electric Motors

for severe radial load duty

Slo-Speed gear motors and Speed-Trol variable-speed motors with reducer have extended-bearing construction on the speed reducer. Distance between bearings on output shaft has been lengthened to increase both radial load capacity

Specify These Aeroquip Hose Lines For Fluid Line Systems Up To 3000 psi.*

AEROQUIP 1503 AND 1502 HOSE is constructed with a synthetic rubber inner tube, a reinforcing layer of single wire braid, and an oil and mildew resistant cotton braid cover. Tube sizes from ¼" through 2½".

AEROQUIP 2651 AND 2652 HOSE features the same tough construction as 1503 Hose, but has an oil, mildew and abrasion resistant rubber cover. Tube sizes from ¼" through 3".

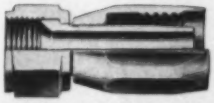
Dash size (in 1/16 in.)	4	5	6	8	10	12	16	20	24	32	40	48
	¼	5/16	3/8	½	5/8	¾	1	1¼	1½	2	2½	3
	3/16	¼	5/16	13/32	½	5/8	7/8	1⅛	1⅜	1 13/16	2⅜	3
	33/64	37/64	43/64	49/64	59/64	1 5/64	1 15/64	1½	1¾	2 7/32	2⅞	3 19/32
	3000	3000	2000	2000	1750	1500	800	600	500	350	250	200
	12000	10000	9000	8000	7000	6000	3200	2500	2000	1400	1000	800
	1 15/16	2 3/16	2⅜	4⅜	5½	6½	7⅜	9	10½	13¼		
	3	3⅜	4	4⅜	5½	6½	7⅜	9	10½	13¼	24	33

*Specify Aeroquip Teflon Hose For Chemical And High Temperature Applications

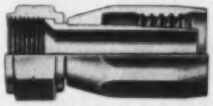
ALL DIMENSIONS IN INCHES

END FITTINGS AVAILABLE

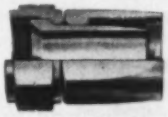
Male Pipe—¼" to 3"



J. I. C. Swivel—¼" to 3"



S. A. E. Swivel—¼" to ¾"



P. T. T. Swivel—1" to 2"

Special Elbow Fittings Are Also Available

Aeroquip 1503, 1502 and 2651, 2652 Single Wire Braid Hose and Reusable Fittings offer many advantages in the design of medium pressure fluid line systems. Recommended for hydraulic, lube and fuel oil, water and air lines, Aeroquip Flexible Hose Lines are superior in installations subject to vibration, stress or flexing. Because of their flexibility, Aeroquip Hose Lines are easy to install in confined spaces, with fewer elbows or adapters than are required with rigid piping or tubing.

REUSABLE HOSE FITTINGS

All Aeroquip Fittings are detachable and reusable. Fittings and hose can be assembled and disassembled quickly. With a supply of bulk hose and reusable fittings, hose assemblies can be made quickly and in quantity in the manufacturer's plant—without need for expensive swaging machines. Another advantage is that hose assemblies on engineering mock-ups can be modified and installed in seconds, using standard bench tools.

The equipment purchaser also benefits because Aeroquip Hose Lines can be replaced quickly and inexpensively right in the field, and the fittings used again and again.

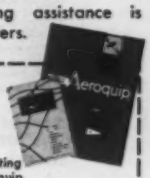
SPECIFY AEROQUIP FOR QUALITY

Aeroquip quality standards are the highest in the industry. From raw materials to workmanship to final inspection, precise, accurate quality control is maintained, resulting in Aeroquip Products that give dependable performance under the most severe operating conditions.

Aeroquip produces a complete line of more than 55 different types of flexible hose—all with matching, reusable fittings—for almost every fluid-carrying application.

Full information is available. Aeroquip Industrial Catalog No. 200 gives complete information on hose, fittings and couplings for industrial applications, plus valuable reference that will help you solve many fluid line design problems. Or write for handy 16-page guide that tells how to plan and install flexible plumbing. Fill in the coupon today.

Complete engineering assistance is available to manufacturers.



Aeroquip Corporation
Jackson, Michigan

☐ Please send Industrial Catalog No. 200.

☐ Please send "Guide for Routing and Installation of Aeroquip Flexible Hose Assemblies."

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

SEE OUR CATALOG PAGES IN SWEET'S PRODUCT DESIGN FILE, SECTION 6d.

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 10, ONTARIO

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USE

Blue Devil

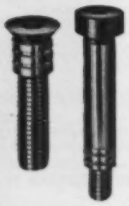
SAF-LOK

SOCKET CAP SCREWS

Here's the best advice we can give you, the right answer to the old problem of vibration. Blue Devil SAF-LOK Screws are available in a complete range of sizes from #6 to 1" for immediate delivery at your Blue Devil distributor. SAF-LOK is the only Socket Screw on the market today that is *absolutely* vibration-proof; an exclusive development of Safety Socket Screw Company.

ALSO SAF-LOK SHOULDER SCREWS AND FLAT HEAD SOCKET SCREWS

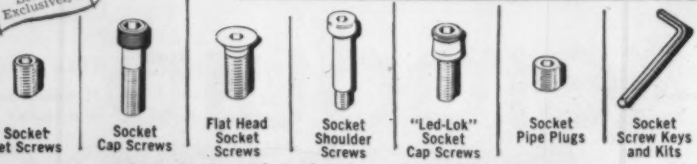
All three types give you an absolute seal against oil, water, gas and air as well as vibration.



Silver Anniversary 25 Years of Socket Screws Exclusively!

I'm Your Blue Devil Distributor

. . . and we can give you the story on this outstanding Blue Devil product, one of a complete line of socket screws. We have them on hand for immediate delivery. Call us today for any Blue Devil Socket Screw requirement.



Member ASMMA **Sold Only Through Authorized Industrial Distributors**

SAFETY SOCKET SCREW COMPANY

6510 North Avondale Avenue • Chicago 31, Illinois

Warehouses at: Los Angeles, San Francisco, Detroit, New Haven, Conn.

New Parts

and rigidity. Gearmotors are available with 1 to 15 hp, variable speed motors with ½ to 15 hp. All standard AGMA speeds are furnished

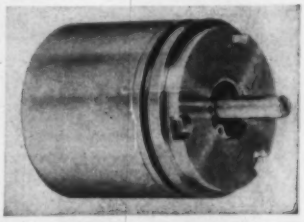
from 20 through 350 rpm in both constant and variable speed models. Both motors incorporate horizontal, vertical or side-wall mounting without modification. **Sterling Electric Motors Inc.,** 5401 Telegraph Rd., Los Angeles 22, Calif.

Circle 690 on page 19

Miniature Gear Boxes

servo components have ratios to 12,000:1

Precision, miniaturized gear boxes are for electronic and instrument applications, servo-mechanisms, computers, small actuators and electronic components. Available in three sizes, units have gear



ratios from 4:1 to 12,000:1. Torque capacity ranges from 45 to 100 oz-in. Precision ball bearings are employed, and units may be mounted directly on small electric motors. Size range is 1 1/16-in. diam by 1.55 in. long to 1¾ in. diam by 1.90 in. long. **Southwestern Industries Inc.,** 5880 Centinela Ave., Los Angeles.

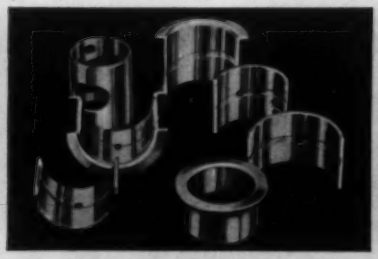
Circle 691 on page 19

Miniature Relay

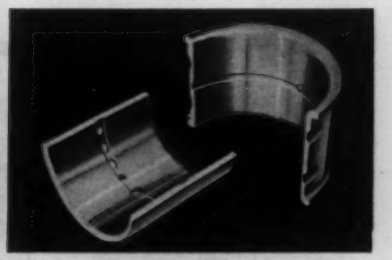
has snap-action contact

Class 22SA open-type relay has enclosed snap-action contact. It is furnished with one snap-action switch for single-pole, double-throw contacts or with two switches for double-pole, double-throw contacts, and is available also with plug-in

CAST BRONZE

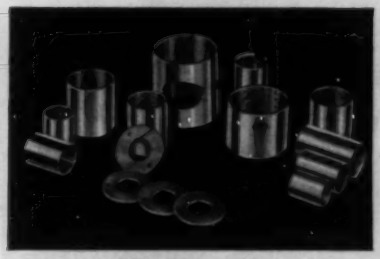


BABBITT AND STEEL

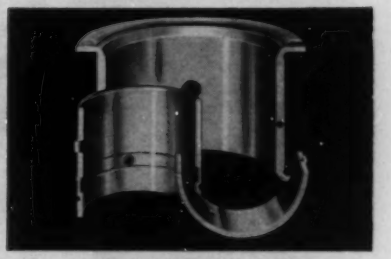


BABBITT AND BRONZE

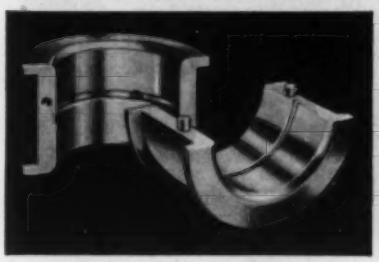
BRONZE OR COPPER-LEAD ON STEEL



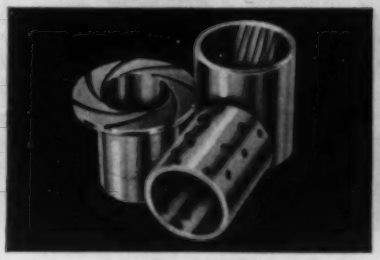
ROLLED BRONZE



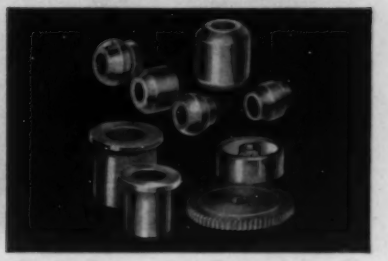
ALUMINUM ON STEEL



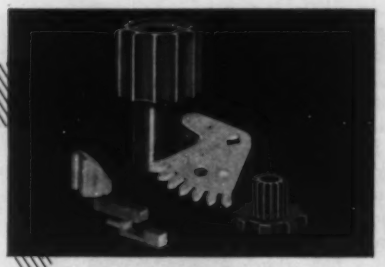
CAST ALUMINUM ALLOY



GRAPHITED BRONZE



LEDALOYL SELF-LUBRICATING



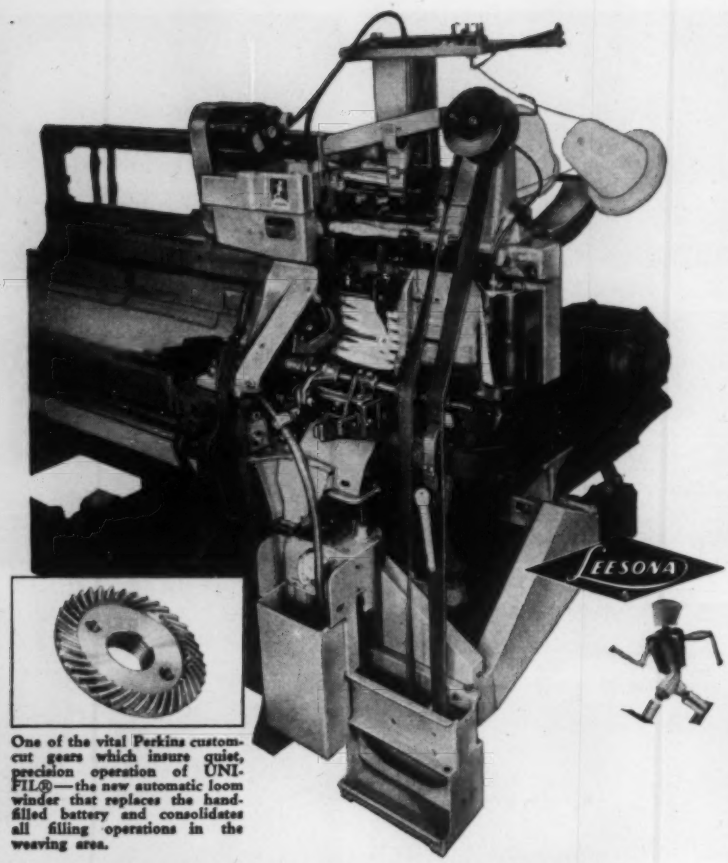
POWDERED IRON

If Sleeve Bearings are your problem...

Johnson Bronze can provide the solution. We produce all types of sleeve bearings in a number of standard sizes. In addition, we have the facilities to produce an infinite variety of custom-made bearings to your specifications. The best bearing for any application can be found among the types illustrated above. To get the exact bearing you need at reasonable cost, contact Johnson Bronze Company, 525 S. Mill Street, New Castle, Pa.

JOHNSON Bearings

Circle 467 on page 19



One of the vital Perkins custom-cut gears which insure quiet, precision operation of UNIFIL®—the new automatic loom winder that replaces the hand-filled battery and consolidates all filling operations in the weaving area.

Perkins Custom-Cut Gears Specified for Universal Winding's New Unifil® Loom Winder

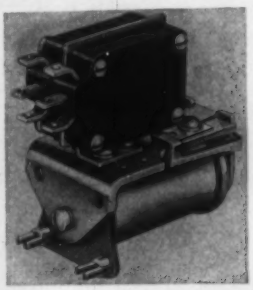
Quality and service determine Universal Winding Company's choice of Perkins custom-cut gears for many of their machines, including the new UNIFIL®. Perkins gears are precisely cut to exact specifications which eliminate noise, wear and backlash. This means fewer rejects, lower maintenance cost and longer gear life. Extensive facilities and modern equipment, backed by 52 years of gear-making know-how insure prompt delivery, as scheduled, to meet production needs. You, too, can benefit from Perkins *quality* and *service*. Perkins can cut your gears from any material — metallic or non-metallic. If you require a special deep or shallow pitch, a gear with a hub, clutch teeth or other special features, Perkins engineers will work with you to insure efficient and economical gear design. Ask us to quote on your next gear requirement.

YOURS ON REQUEST — Folder illustrating gears Perkins has made — face gears, generated and curvic clutches; bevel, spiral, helical and spur gears; ratchets, sprockets and ground thread worms . . . from all materials. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

Dept. 13 West Springfield, Mass.
Telephone: REpublic 7-4751

New Parts



mounting. Contact rating is 10 amp at 115 v ac, noninductive load. Relay is furnished for dc operation to 230 v and 60 cycle ac to 440 v. Approximate dimensions are 2⅜ in. long, 1⅞ in. high, and 1 1/16 in. wide. **Magnecraft Electric Co.**, 3350T W. Grand Ave., Chicago 51, Ill.

Circle 692 on page 19

Shaped Wire

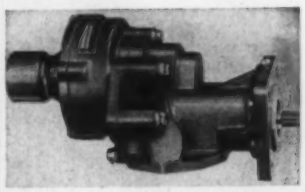
is heat and corrosion-resistant

Combination drawing and rolling process creates shaped wire and rod of Monel, Inconel, Inconel X, nickel and stainless steels, and other heat and corrosion-resisting alloys. Wide variety of shapes is available with maximum dimension of ½-in. Sizes as small as 0.002-in. have been manufactured. Advantages include low cost, elimination of tool marks, smooth surfaces, stronger and tougher shaped wire. Packing includes coils, spools or straight length. **Techalloy Co. Inc.**, Rahns, Pa.

Circle 693 on page 19

Fuel Pump

for gas-turbine fuel systems



This compact, lightweight fuel pump is a rotary-gear, positive-displacement type with built-in centrifugal booster pump and mounting pad. Aluminum pump body contains inlet port, discharge port,

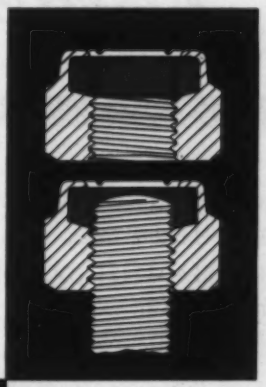
What's special about this STOP NUT?

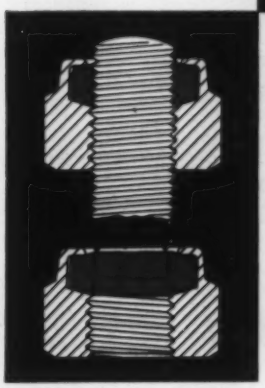
Several things make this nut unusual. For instance, you can "stop" it at any position on the threaded length of the bolt . . . or wrench it tight against the work where it protects bolt threads against corrosion and prevents liquid leakage. No matter where you leave it on the bolt, it will remain tight in that exact position, even though you subject it to heavy vibration and shock loads. But use a wrench on it and it comes off as easily as it went on. The red locking collar is nondestructive—does not gall bolt threads or remove plating. You can remove it and re-use it again and again.

What gives it its grip?

1 The locking collar is unthreaded and elastic. It has an inside diameter smaller than the major diameter of standard bolts.

2 The bolt impresses a mating thread into the collar and the resulting compressive forces exert a constant friction grip on the bolt. . . .





3 and exert a downward thrust bringing the lower flanks of the bolt thread into firm metal to metal contact with the matching nut threads, eliminating normal axial play.

4 Nut is removable and reusable . . . the Red Elastic Collar retains its grip after repeated usage.

Will it hold under ALL conditions?

The locking principle of the Elastic Stop® nut has been tested and proved by over 25 years of actual field service. Elastic Stop nuts are used on locomotives . . . and pile drivers. They fasten hedge shears and harvesters, drilling rigs and washing machines, trucks and roller skates. And no Elastic Stop nut customer has ever stopped using them because of unsatisfactory performance.

What about sizes and materials?

Elastic Stop nuts are available from a watchmaker's 0-80 all the way to 4"—in materials that include stainless steel, brass, aluminum and other alloys. Protect your product with "fastener insurance." Try Elastic Stop nuts on trouble spots, whether to protect expensive heavy equipment from costly downtime or to guarantee the accuracy of delicate electrical equipment by maintaining precision adjustments. We'll supply free test samples.

ESNA® TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA

Dept. N82-34, 2330 Vauxhall Road, Union, N. J.

Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name _____ Title _____

Firm _____

Street _____

City _____ Zone _____ State _____

Circle 469 on page 19

SHIPBOARD MOTORS

SPRAY-TIGHT SERVICE "A"

MARINE DUTY

BY Peerless

These Peerless motors meet all critical marine codes. Spray-tight Service "A" units withstand tremendous shock, high vibration levels and great temperature changes. To remove one costs almost as much as a new motor. They must be flawless.

The Peerless Marine Duty Motor is available in drip-proof, splash-proof, totally enclosed, spray-tight and water-tight construction from 1/2 HP to 30 HP.

Both Motors meet specifications of ABS, Mil-M-17431 (DC), Mil-M-1706A (AC), AIEE 45 and U. S. Coast Guard. With standard or special mountings and features, they serve aboard vessels throughout the world. Give us your shipboard motor problem. We'll work with your engineers to produce the one motor that serves your needs best.

ELECTRIC MOTOR DIVISION

THE Peerless Electric® COMPANY

FANS · BLOWERS · MOTORS · ELECTRONIC EQUIPMENT

1520 W. MARKET ST. · WARREN, OHIO

Circle 470 on page 19

and port for relief-valve return line. Pump has a square, four-hole mounting flange and spline drive shaft. Mechanical shaft seal is flexible type, self-aligning for shaft misalignment, providing total seal against leakage. Rated capacity is 9.4 gpm at 6000 rpm and 700 psi gage discharge pressure. Power requirement is 8.4 hp maximum at rated capacity. Displacement of gear pump is 0.52-cu in. per revolution. **Lear Inc.**, Lear-Romec Div., Elyria, O.

Circle 694 on page 19

Digital Dial

for use with multiturn devices

Ten-turn Digidial gives direct numerical readings in full turns, tenths and hundredths. The lightweight, ruggedly compact unit is designed for use with multiturn devices such as precision potentiometers, variable condensers and similar components. Reading resolution is 0.05 per cent. Unit has a friction lock which can be engaged without disturbing dial setting. **Beckman Instruments Inc.**, Helipot Div., Newport Beach, Calif.

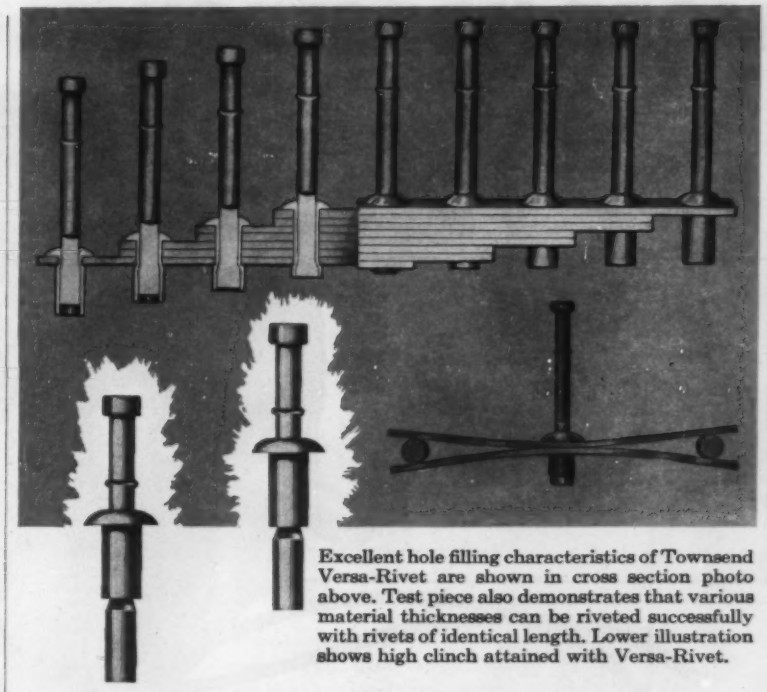
Circle 695 on page 19

Hydraulic Connector

withstands pressures to 2500 psi

B-100 hydraulic connector divides flow equally between two cylinders which may have different loads. Unit features homogenous cast-

(*Continued on Page* 140)



Excellent hole filling characteristics of Townsend Versa-Rivet are shown in cross section photo above. Test piece also demonstrates that various material thicknesses can be riveted successfully with rivets of identical length. Lower illustration shows high clinch attained with Versa-Rivet.

New Townsend Versa-Rivet* Provides Versatile, Uniform Fastening Method

The hole filling qualities, wide grip range, high clinch, and positive stem retention now possible with the new Townsend Versa-Rivet give industry a uniformity of fastening never before available.

In the past, variations in hole diameter made it virtually impossible to completely fill the hole in every instance. The Versa-Rivet always adjusts to fill the hole, and in addition provides uniformly high stem retention.

The method of setting the Versa-Rivet also provides high clinch and makes it possible to use one length to fasten a wider range of material thicknesses. Positive inspection is easy since a properly set rivet is indicated by the amount of stem shoulder protruding above the rivet head.

The Versa-Rivet is available in the universal head with one length for each diameter. It is installed with standard Townsend rivet guns with controlled-stroke pulling heads and accessories.

For technical data on how the Townsend Versa-Rivet will give you a more uniform method of fastening, write to Townsend Company, P.O. Box 237-E, New Brighton, Pa.

*Patents issued and pending

The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

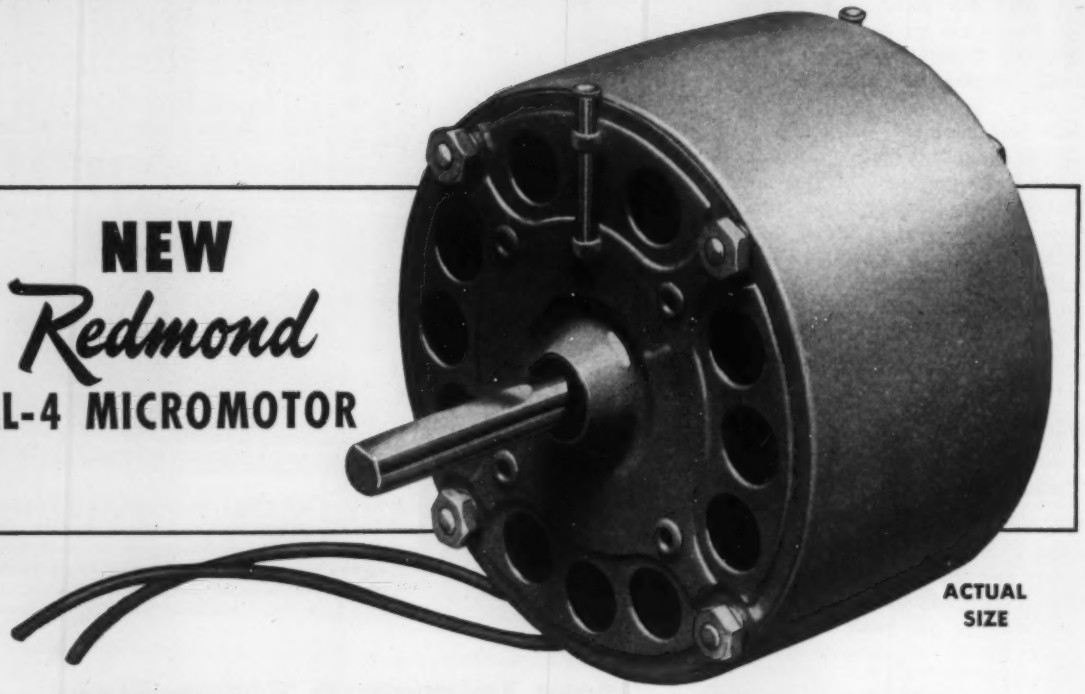
Cherry Rivet Division • Santa Ana, California

In Canada: Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario

Circle 471 on page 19

MORE HORSEPOWER in an Economical,

NEW *Redmond* AL-4 MICROMOTOR



ACTUAL SIZE

Designed for a Wide Variety of Applications . . . or can be Tailor-Made for Specific Requirements

Here is a motor designed and styled to meet the modern demands for motors that are smaller, and lighter, and yet have increased output. It is ideal for heating, ventilating, air conditioning or refrigeration equipment, for appliance applications, and for business and vending machines, pumps, tape recorders, and dozens of other applications.

The patented Redmond Tri-Flux design, which is illustrated and described in the box below, greatly increases the efficiency and starting and running torques of the new AL-4 over conventional motors of this size.

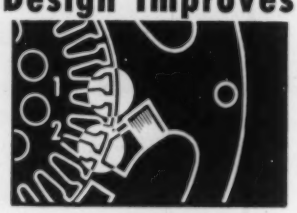
The Redmond Uni-Cast construction allows the precision manufacturing that results in a motor that is smooth-running and quiet in operation and that can be depended on to give years of service-free performance and whisper-quiet operation.

The basic AL-4 is a 4-pole motor, 1550 r.p.m., 115 volts, 60 cycles. It is also available in odd voltages and frequencies, or in either open ventilated or totally enclosed construction. It develops 1/250th to 1/15th horsepower.

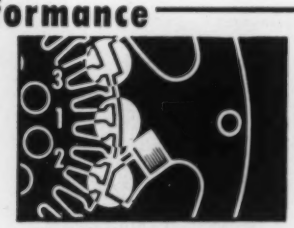
This modern motor can save money on a host of applications where economy is a factor and yet high quality is needed. If you are looking for a motor in volume quantities, let us know and we will have a sales engineer in your area contact you at once.

How Tri-Flux Design Improves Performance

The salient pole single phase induction motor has only one flux path—indicated by the white circle—between the field and the rotor. The motor is not self-starting—for commercial value a starting mechanism must be added.



The second white circle indicates the flux path added by wrapping a shading coil around the trailing pole tip. Power and uni-directional action are increased in this shaded pole induction motor, and it is now self-starting. This motor is now practical at low cost, and is used for applications requiring limited starting torque.



Note that a third flux path has been added at the leading pole tip. This was accomplished by Redmond's Tri-Flux design, whereby a "reluctance notch," which can be seen in the third white circle, is put in the leading pole tip. Efficiency and starting and running torques are greatly increased. New applications are opened to these improved, low-cost motors.

Compact, Lightweight, Quality Package

STANDARD AL-4 RATINGS

Open Ventilated FAN DUTY

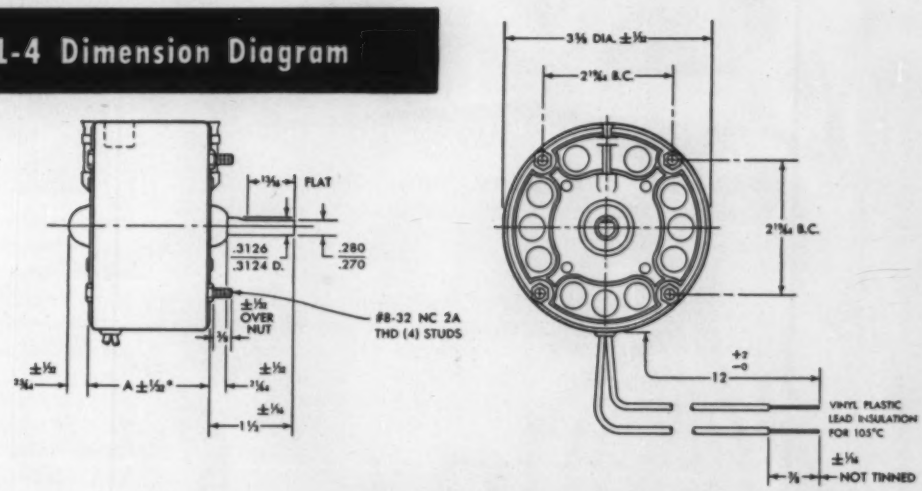
115V • 60 CYCLES • 4-POLE • 1550 RPM • ANY POSITION MOUNTING

Model Number	H.P.	Nominal Amps	Nominal Watts	Oz. in. Torque		A±1/32*	Weight lbs-oz.	Notes
				Start	Load			
AL4700A	1/15	2.25	150	18	45	3 9/32	4—10	(1) Horsepower ratings less than 1/75 horsepower available as developed for the specific application involved.
AL4701A	1/20	1.82	120	15	33	3 9/32	4—10	
AL4400A	1/25	1.6	105	13	27	2 23/32	3— 8	(2) Totally enclosed motors are available in all sizes in reduced horsepower ratings.
AL4300A	1/30	1.35	95	11	22	2 13/32	3—00	
AL4200A	1/40	1.2	85	9	17	2 5/32	2— 8	(3) All standard model numbers are clockwise rotation face shaft end of motor. Opposite rotation supplied on request.
AL4000A	1/75	.91	60	6	9	2 1/32	2—00	

Motors are supplied standard as shown. Also available are other features of special single or double shaft extensions, 5/16" and 3/8" shaft diameters, special casebolt extensions, sleeving over leads, other lead material including multi-conductor cords, feed-thru switches, plugs, terminals, thermal overload protectors, conduit clamps, conduit boxes, triangular mounting brackets, and special or extended oilers.

Other performance ratings for various voltages, frequencies, and loads can be supplied for your product. Our sales engineers will welcome the opportunity to assist you in developing the most practical motor for your applications.

Basic AL-4 Dimension Diagram



SEND FOR COMPLETE PERFORMANCE DATA

For the complete story on the new AL-4 motor—dimensions, performance, operational data, and suggested applications—write for the "AL-4 Bulletin."

The Standard of Dependability

Redmond

COMPANY, INC.

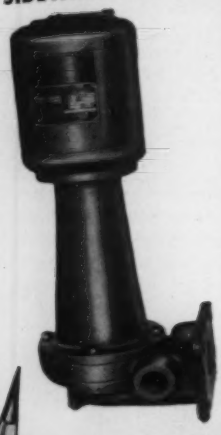
OWOSSO, MICHIGAN

ADVERTISED IN The Saturday Evening POST

THE **BIG** NAME IN SMALL MOTORS

NEW DESIGN FLEXIBILITY with VERSATILE IR PUMPS

FOR SIDEWALL MOUNTING



FOR IMMERSION

long-shaft, packingless pumps improve handling of coolant, cutting oils and washing liquids.

High production machines like grinders, lathes, drills, etc., industrial washers or spray bath machines depend on their integral components for sustained, trouble-free operation. This is why these Ingersoll-Rand Motorpumps are being recommended by design men everywhere.

- Packingless – long life, less maintenance, no leaks.
- Long Shaft – higher liquid level, lower draw down.
- Motor Protection – vent hole near head prevents flooding.

Other compact Motorpumps are available in sizes ¼ hp to 75 hp. Get the interesting performance data on Ingersoll-Rand Centrifugal pumps now.

Ingersoll-Rand

9-488 ♥ 11 Broadway, New York 4, N. Y.

Circle 473 on page 19

New Parts

(*Continued from Page* 137)

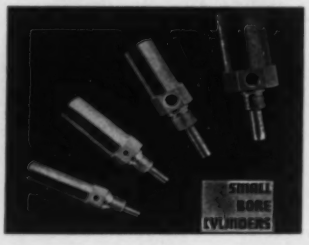
iron body with hardened and ground spool. Spool and body are mated by selective honing to assure accurate dividing. Valve automatically locks when cylinder travel stops, thus preventing transfer of oil from heavy side to lighter side. It also has rapid flow return and wil not slow down gravity return operations. Tee is available with ¼, ⅜, ½ and ¾-in. NPT ports, and withstands pressures to 2500 psi. **Brand Hydraulics,** 144 S. 38th St., Omaha, Neb.

Circle 696 on page 19

Miniature Air Cylinders

have bores from ⅜ to 1½ in.

Miniature air cylinders for use in light production positions or new products have bores of ⅜, ¼, ¾ and 1½ in. They are designed with ⅛-in. thick brass tube wall. Blind ends are silver-brazed to



the tube; front gland piston-rod end is internally threaded. They are designed for activating electrical contacts, in test jigs and fixtures, as miniature air vices, and in automatic work for feeding, ejecting, soldering, welding, brazing, stamping, bending, marking and assembly operations. **Airmatic Valve Inc.,** 7317 Associate Ave., Cleveland 9, O.

Circle 697 on page 19

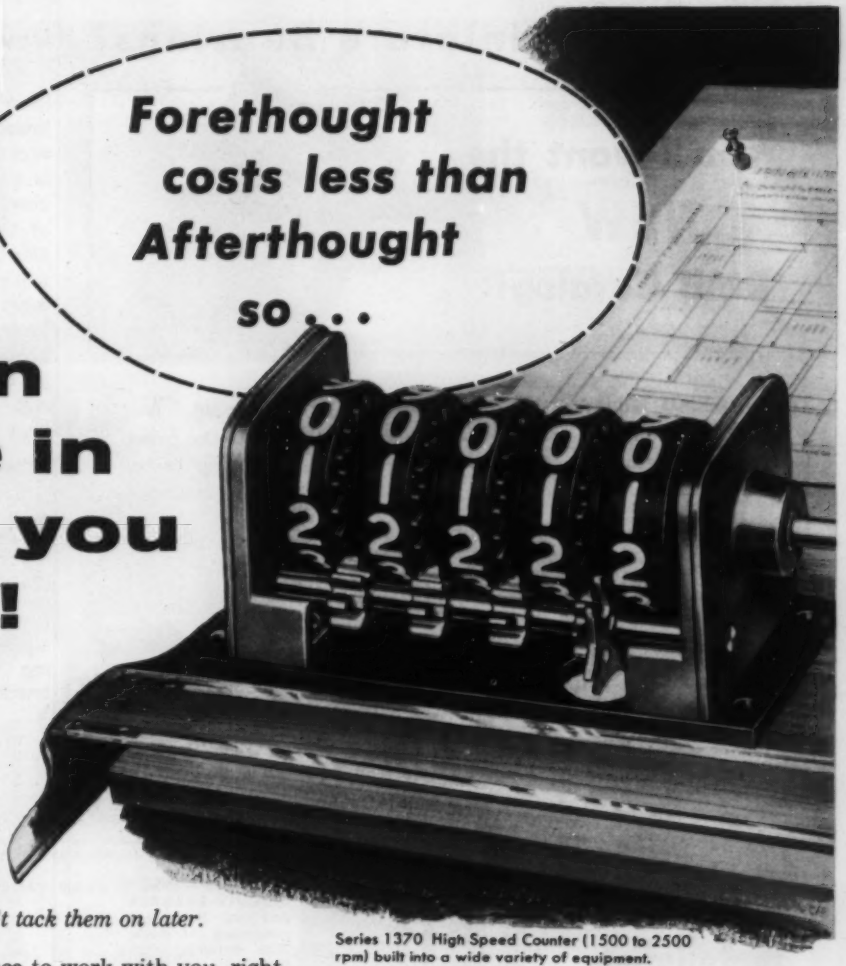
Color Dip

for copper and copper-base alloys

Enthocolor 220 is an alkaline salt mixture which produces brown and shiny blue-black oxide coatings on copper and copper-base alloys. Uniform brown colors are produced on copper and almost all copper alloys. Blue-black and

Forethought costs less than Afterthought so . . .

Design These in When you Begin!



Series 1370 High Speed Counter (1500 to 2500 rpm) built into a wide variety of equipment.

If you need mechanical or electrical counters in any of your new products, here's a word to the cost-wise designer: *Design them in, when you begin . . . don't tack them on later.*

For if you'll give us a chance to work with you, right from the beginning, chances are we can save you time and money by adapting or modifying a *standard* Veeder-Root Counter to your needs . . where you might get into a costly special job if you went about it alone. What's more, you save time in your engineering, purchasing and assembly departments.

Count on Veeder-Root to help you in every way . . . from design to delivery. Write:

Everyone... Can Count on Veeder-Root

INCORPORATED

Hartford, Conn. • Greenville, S. C. • Chicago
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Series 1205 Reset Magnetic Counter with panel mount and lock and key.

Series 1122 Small Reset Ratchet Counter.

Special Longitude Counter, one of many made for aircraft navigational equipment.

Work with Miniature Bearings?

You'll want the
NEW
RMB Catalog!

The new RMB Miniature Bearing Catalog is now available. And what a compendium of useful information it is! Just off the press, it contains a listing of and all vital information pertaining to the function and use of the famous RMB line of miniature bearings.

Included in the RMB Miniature line are:

1) Miniature Radial Filmoseal® Sealed Bearings*
2) Miniature Radial Bearings*
3) Miniature Radial Ultra-Light Bearings*
4) Miniature Roller Bearings
5) Miniature Pivot Bearings (with or without inner race)
6) Miniature Radial Bearings Without Inner Race
7) Miniature Special Bearings*

*available in several inch sizes, and in ABEC Class 1 tolerances as well as ABEC Class 5.

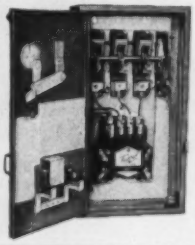
If you work with miniature bearings, there's an RMB Bearing for your application. Get a copy of our new catalog and then order some RMB miniature bearings—experimental quantities from stock.

LANDIS & GYR, INC.
45 West 45th Street New York 36, N. Y.

Circle 475 on page 19

slash installation costs with FEDERAL PACIFIC Combination Motor Starters

THERMAL MAGNETIC CIRCUIT BREAKER permits harmless temporary overloads; trips instantly when overload becomes dangerous... offers quick-make, quick-break action, thermal tripping element and deionization arc quenchers.



DISCONNECT SWITCH designed for cool operation, safety and long life. Features clear visibility, positive circuit opening and silver plated current carrying parts.

NOW Federal Pacific does away with the need for separate motor controls and safety switches or circuit breakers! Now you can meet all your needs with one simple space-saving device... and save money while you do it! You install only one device—save valuable time—conserve precious space! Faster, easier installation more than offsets the slightly additional cost.

Finest Products Engineered
FEDERAL PACIFIC ELECTRIC COMPANY
50 Paris Street, Newark 1, N. J.

New Parts

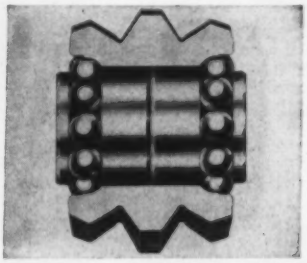
brown colors are produced on brasses containing at least 20 per cent zinc. Adhesion of the finishes is excellent, and parts can be severely deformed without flaking of the coating. The dip is used at 180 to 225 F, and parts are immersed from 1 to 15 minutes. Finishes can be used in place of brown lacquers, enamels or sulphide finishes. They are also used as bases for painting or blackening. **Enthone Inc.**, 442 Elm St., New Haven, Conn.

Circle 698 on page 19

Ball Bearings

for use in steering mechanisms

Roller-tooth ball bearings are designed for use in the manual steering mechanism of automobiles, trucks and tractors, and can be

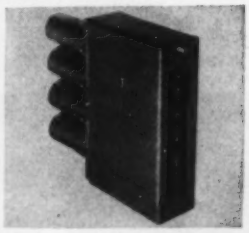


adapted readily to other applications. Profile of the bearing outer ring permits it to engage a worm gear on the steering shaft. **Marlin-Rockwell Corp.**, 402 Chandler St., Jamestown, N. Y.

Circle 699 on page 19

Decimal Counter

electronic unit adds and subtracts



Add-Tractor unit does counting, summing and subtracting, and also can be used for servo control, net weighing, digital position control, ratio control, subtractive mixing,

Circle 476 on page 19

RUGGED

Manufacturers of the big diesel transports, that must stand up under hour-after-hour of gruelling service, have learned to rely upon MECHANICS Roller Bearing UNIVERSAL JOINTS to deliver hundreds of thousands of miles of trouble-free service. Because MECHANICS JOINTS drive through KEYS—instead of bolts—they stand up under punishment that shears off other types of fasteners. They are designed with less parts and connections for easy assembly and servicing—smooth running balance—maximum strength with less weight—and long, trouble-free, safe operation. Rugged stamina is just one of the advantages you get when you specify MECHANICS Roller Bearing UNIVERSAL JOINTS. Let MECHANICS engineers help you design this and other competitive sales features into your product's transmission train.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International
79 E. Adams, Chicago 3, Illinois

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

GASOLINE
GREASE
HYDRAULIC FLUIDS
OXYGEN
WATER
WHAT'S Your COUPLING APPLICATION?
STEAM
AIR
VACUUM
OIL
ACETYLENE
REFRIGERANTS
COOLANTS
SPECIFICALLY ENGINEERED
...NEVER MERELY ADAPTED
...FOR EACH PARTICULAR
TYPE OF APPLICATION
HANSEN

QUICK-CONNECTIVE COUPLINGS

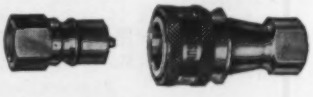
For Pneumatic or Hydraulic Line Circuits

Regardless of whether your particular application requires One-Way Shut-Off, Two-Way Shut-Off or Straight-Through Couplings—or couplings for special service on fluid lines carrying oxygen, acetylene, steam, etc.—you can always select a Hansen Coupling specifically engineered for your requirements.

As the result of years of experience with fluid line circuits on many different types of manufactured units, all Hansen Couplings are carefully designed to incorporate the specific features needed for the job they are intended to do.

The next time you are planning to design a fluid line circuit, make use of the know-how of your nearest Hansen representative. You'll find him a real help in getting exactly the couplings you need to do the job.

ONE-WAY SHUT-OFF



TWO-WAY SHUT-OFF

STRAIGHT-THROUGH COUPLING

Write for the Hansen Catalog

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes and types of Hansen Quick-Connective Couplings. Write for your copy.

Representatives in Principal Cities

SINCE 1915 QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

4031 WEST 150th STREET • CLEVELAND 11, OHIO

New Parts

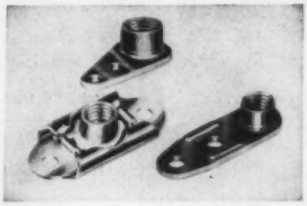
frequency deviation measurement, random-events difference counting, digital to analog conversion, computer arithmetic elements and similar applications. Counter will nine's complement its stored value in 10 microseconds. It accepts digital information serially as a unitary pulse train, or in parallel in binary coded decimal form. Unitary decimal can be counted at rates up to 100,000 per second. **Victor Adding Machine Co.**, 3900 N. Rockwell St., Chicago 18, Ill.

Circle 700 on page 19

Anchor Nuts

fixed and floating units have thread-relief design

Lightweight Kaylock fixed and floating self-locking anchor nuts and gang channel are available with thread relief in sizes from 8-32 through ⅜-24. Design, which permits bolt grip to enter the base



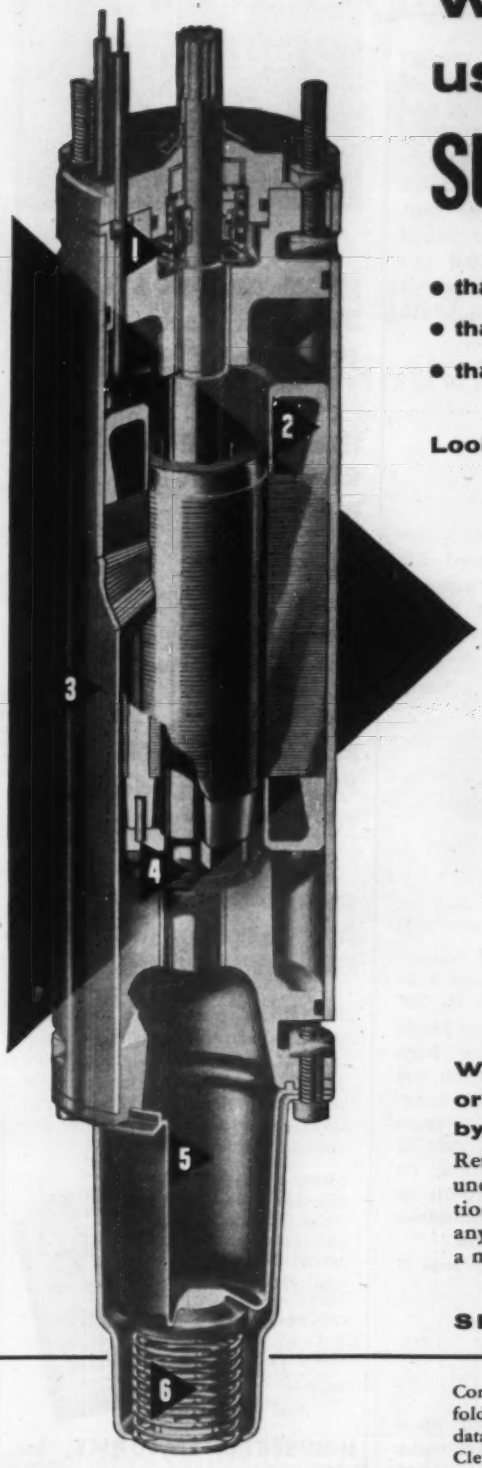
of the nut, reduces need for shims and changes in bolt-grip lengths. It also helps to insure a structurally sound joint by eliminating threads in bearing. All nuts are approved for use at temperatures to 550 F. **Kaynar Co.**, Box 2001, Terminal Annex, Los Angeles 54, Calif.

Circle 701 on page 19

Motor-Generator Set

changes 60-cycle ac to 400-cycle ac current

Frequency changing, synchronous motor-generator set, with recovery time of less than 0.15 seconds, changes 60-cycle ac to 400-cycle ac. Motor and alternator are encased in common frame with single-shaft, two-ball-bearing construction. The 60-cycle motor is 75 hp; motor exciter, 1500 w. The 400-cycle dc-field alternator is 50 kw at 80 per cent power factor and 62.5 kva. Voltage selection is 120/208. Regu-



Where can you use a *CUSTOMIZED* SUBMERSIBLE MOTOR?

- **that can be made in any length-diameter ratio?**
- **that gives high output?**
- **that runs in water, oil, or other fluids?**

Look at typical features of a J&H Underwater Motor

1 *Rotary Seal*—Ceramic and graphitar faces, carefully lapped to insure against entry of water and contaminants.

2 *Encapsulated Windings*—A special J&H epoxy compound is used for "potting." Epoxy has exceptional heat conductivity and does not buckle or swell under many abnormal conditions. "Potting" prevents winding failure, even if water enters motor. In fact, motor will operate as water-filled unit.

3 *Corrosion-resistant Epoxy Paint Finish.*

4 *Segmented Tilting-shoe Self-aligning Thrust Assembly*—Ample reserve thrust carrying capacity is provided. Faces accurately lapped for long wear.

5 *Oil-filled Motor*—A large reservoir of oil provides additional dielectric strength, insures longer seal and bearing life, protection against corrosion.

6 *Controlled Pressure System*—Diaphragm and spring assembly insures an internal pressure sufficient to prevent infiltration by external contaminants, which could occur with normal seal wear.

● *L/D Ratio To Suit*—Length/diameter ratio can be varied to fit casing, tank, pipeline or other designated location.

Whether you're pumping water, crude oil, gasoline or other fluids, your motor need can be met quickly by Jack & Heintz!

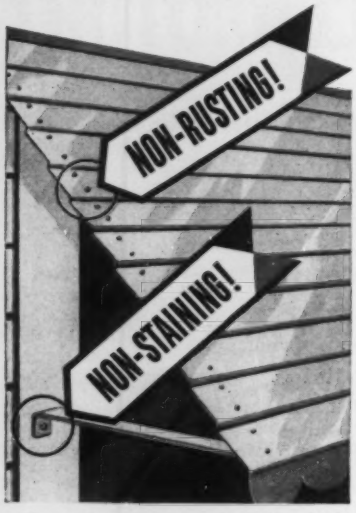
Retaining the size flexibility and long service life features of the underwater motors, J&H designers have already developed modifications for operation in crude oil, gasoline and other fluids. Customizing any of the proved basic designs to meet your specific needs is only a matter of defining your service and dimensional requirements.

SEND FOR DATA TODAY

Confer with J&H motor specialists or write for folder which gives rating and performance data: Jack & Heintz, Inc., 17626 Broadway, Cleveland 1, Ohio.

JACK & HEINTZ ***CUSTOMIZED*** ELECTRIC MOTORS

How Alcoa Aluminum Fasteners make good awnings even better



Alcoa® Aluminum Fasteners guard your reputation for quality aluminum awnings. They insure against both galvanic and atmospheric corrosion. They provide perfect color match and lasting good looks. Specify Alcoa Fasteners for assembly and installation. Your local Alcoa distributor carries complete stocks for every requirement. He is listed in the Yellow Pages of your telephone directory.

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2244-C Alcoa Bldg., Pittsburgh 19, Pa.

Gentlemen:
Please send complete specification data and samples of Alcoa Aluminum Fasteners.

Name_____

Title_____

Company_____

Address_____

Circle 480 on page 19

New Parts

lation of generator output voltage is by magnetic-amplifier control of primary source of excitation, and is kept within ±1 per cent from no load to full load. Harmonic content is less than 1 per cent on line to line and less than 3 per cent from line to neutral. Amplitude modulation is less than 0.6 per cent with balanced or unbalanced load. **Kato Engineering Co.**, 1415 First Ave., Mankato, Minn.

Circle 702 on page 19

Variable-Speed Drive

in sizes from 1/15 to ½-hp

High-accuracy, stepless variable-speed drive meets the need for lightweight 400-cycle aircraft ground checkout and test equipment, such as tachometer, gyro and accelerometer testers, integrating devices and other apparatus. Speeds can be varied from any desired maximum to zero and into full reverse without change of motor rotation. Sizes from 1/15 to ½-hp with torques up to 750 lb-in. are available. Drive meets military specifications for high and low-temperature operation and has twelve-pole, lightweight, fungus-treated motor. Speeds from 10,000 rpm to zero or 11 rpm to zero are available, depending on type of built-in gear step-up or reduction. **Graham Transmissions Inc.**, Menomonee Falls, Wis.

Circle 703 on page 19

Gold Lacquer Coating

for extreme outdoor exposure

Lacquer formulation based upon ½-sec butyrate has nontarnishing properties, great durability, and excellent adhesion. The butyrate, a low-viscosity cellulose ester, is a film former for lacquers and gives excellent color retention, brightness, and gloss under severe out-

Do you need
PRECISION *anti-friction* BEARINGS

for **HIGH-TEMPERATURE SERVICE** to 500° F — 1000° F — 1500° F ?

for **RESISTANCE TO CORROSION** by Acids — Caustics — Salts ?

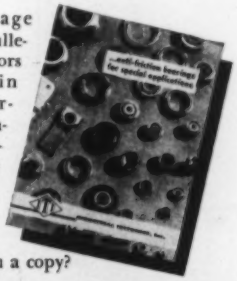
for **RESISTANCE TO ABRASION** by wet or dry grit, silt, etc. ?

with **NON-MAGNETIC PROPERTIES,** electrical conductance, etc. ?

with **SPECIAL SHAPES AND SIZES,** low torque, ultra precision . . ?

WE MAKE bearings to these and other special requirements, in experimental and production quantities. We've been doing that for years, for well-known firms. So if *you* need special anti-friction bearings for *any* application, let's talk it over.

FREE 32-page Bearings Bulletin tells factors involved in special bearing applications — describes our work in this field.



May we send you a copy?

INDUSTRIAL TECTONICS, Inc.
3671 Jackson Rd., Ann Arbor, Michigan
18330 Santa Fe Avenue, Compton, California

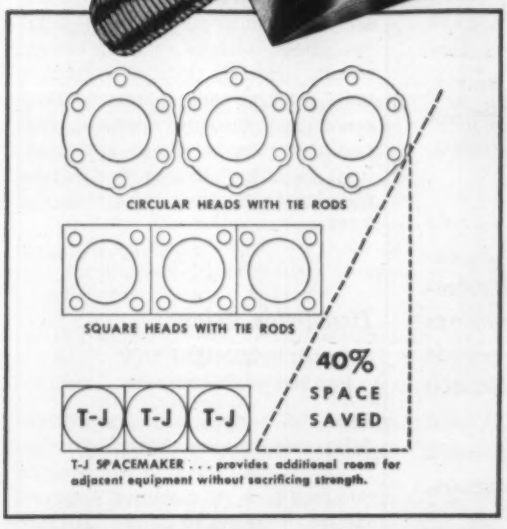
PRECISION BALLS AND SPECIAL ANTI-FRICTION BEARINGS

Circle 481 on page 19

Saves 40% Space!

STRONGER, TOO

Than Outmoded Tie Rod Cylinders!



Only T-J Spacemaker CYLINDERS

Offer All The Extras As Standard!

- **NEW *exclusive* Ingenious Cushion Designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Oil Cushion**
- **Compact design eliminates tie rods, saves up to 40% space**
- **Proven Performance . . . with Extra High Safety Factor**
- **Hard Chrome Plated Bodies and Piston Rods (Standard, at no extra cost).**
- **OIL pressure to 750—AIR to 200 P.S.I.**

You'll find many answers to *automation* in your plant with T-J Spacemaker Cylinders! Designed with years-ahead features for top performance and dependability. Wide range of styles, capacities . . . for all kinds of push-pull-lift operations . . . reduces man-hours and costs! Write The Tomkins-Johnson Co., Jackson, Michigan.

NEW LITERATURE . . . send today for new Bulletin with complete details of Spacemaker line.

MEMBER OF THE NATIONAL FLUID POWER ASSOCIATION

T-J TOMKINS-JOHNSON

RIVITORS . AIR AND HYDRAULIC CYLINDERS . CUTTERS . CLINCHORS

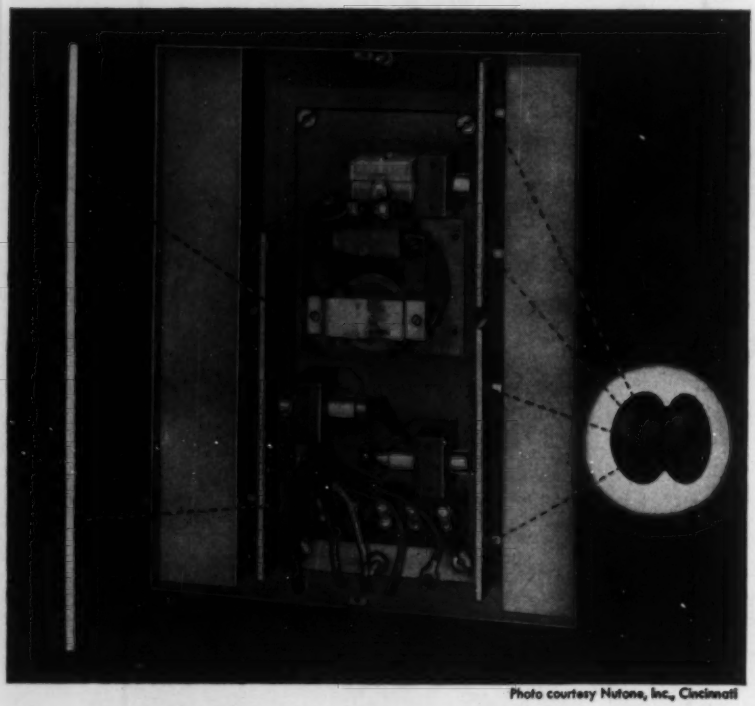


Photo courtesy Nutone, Inc., Cincinnati

Engineers Develop New Use for Rubber

Rubber, normally used to *reduce* vibration, now can be made to *increase* vibration

Here rubber grommets serve as mountings for the tone bars in Nutone Door Chimes. To obtain maximum tone quality and resonance required of these musical chimes, the grommets must vibrate compatibly with the tone bars . . . a truly *unusual assignment* for rubber.

Only by skillful compounding can rubber be diverted from its normal dampening characteristic and be given this vibrant quality. The slightest deadening effect would destroy the rich tones and kill the tone hang.

The successful development of this lively, age-resistant rubber stock typifies the complete engineering and laboratory—as well as manufacturing—skill available at Continental. Whenever you need "engineered rubber parts" — molded or extruded, natural or synthetic—call Continental, Specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**

engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

New Parts

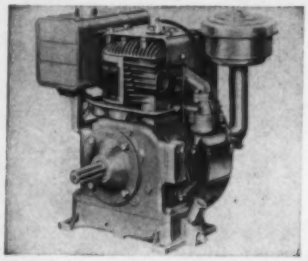
door exposure. Butyrate-lacquer gold coating has minimum field life of three to five years. Material adheres well to cold-rolled steel, galvanized steel, aluminum or cast iron. Parts are primed with zinc-chromate, coated with the lacquer and air-dryed for 15 min. Final coat of clear alkyd lacquer provides high-sheen finish. **Eastman Chemical Products Inc.**, 260 Madison Ave., New York 16, N. Y.

Circle 704 on page 19

Gasoline Engine

develops 7 hp at 3600 rpm

Model 19 single-cylinder, 4-cycle gasoline engine develops 7 hp at 3600 rpm. It has a 3-in. bore, $2\frac{5}{8}$-in. stroke, and piston displacement of 18.56 cu in. Base, cylinder head, bearing supports, piston and connecting rod are made of aluminum alloy; weight is only 78 lb. Special equipment includes rotating blower screen, electric starter-generator unit, starting crank, remote governor and throttle controls, fuel pump, automatic choke and ignition shielding. **Briggs & Stratton Corp.**, 2711 N. 13th St., Milwaukee 1, Wis.



Circle 705 on page 19

Time-Delay Relay

small, lightweight unit has one to six contacts

Type 825 hermetically sealed time-delay relay measures approximately $2\frac{3}{8} \times 2\frac{3}{8} \times 3\frac{5}{16}$ in. and weighs 30 oz or less. It meets all environmental requirements for aircraft and ground installations, is available with from one to six contacts, and has time cycles from fractional seconds to multiple hours. Synchronous timing motor is for 60 and 400-cycle applications. For dc

Circle 483 on page 19

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern appliance design

Make it more attractive—longer-lasting—easier to keep clean. And keep it simple to make. More and more designers "build in" such powerful selling points with stainless steel.

Stainless keeps pace with modern trends. Now there are more than 30 different types and a variety of textures, surface tones and colors. The hard-selling values of superior corrosion resistance, durability and toughness, long associated with stainless give you assurance of consumer acceptance at the point-of-sale.

For more facts about stainless steel and the contribution it can make to your product or marketing problems, see your stainless steel supplier or write ELECTROMET—leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steel. Ask for the booklet "Stainless Steel in Product Design." Address:

ELECTRO METALLURGICAL COMPANY
A Division of
Union Carbide and Carbon Corporation
30 E. 42nd Street UCC New York 17, N. Y.
In Canada: Electro Metallurgical Company, Division of Union Carbide Canada Limited, Welland, Ontario

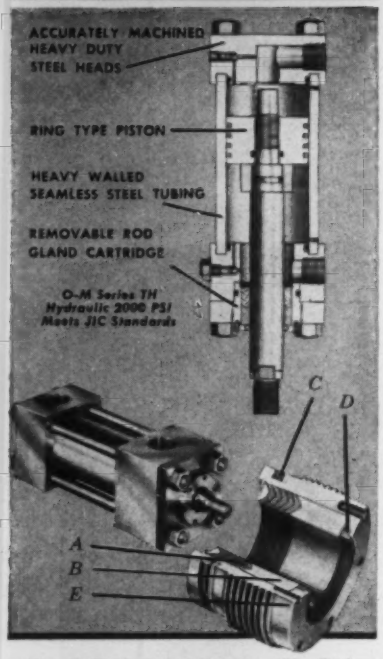
METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

Electromet
Trade Mark
FERRO-ALLOYS AND METALS

Stainless steel styling adds the attractive, durable, "easy-to-clean" appeal which is helping to put across this new idea in cooking units.

Circle 484 on page 19

New O-M High Pressure Hydraulic Cylinder equipped with Removable Rod Gland Cartridge



The O-M-engineered removable Rod Gland Cartridge is constructed with a heavy wall steel shell threaded for quick, easy removal, and accurately piloted in rod head to assure perfect alignment. In most applications cartridge can be removed easily without removing mounts or the rod nuts. You simply loosen and remove with a spanner wrench.

A *Rod Packing* — Vee type, non-adjustable, self-compensating, rod gland packing provides multiple lip seal with excellent pressure sensitivity and long life.

B *Rod Bearing* — Extra long, bronze rod bearing provides large bearing surface located well forward for maximum support of piston rod.

C *Cartridge "O" Ring Seal* — With leather back-up washer provides positive seal and acts as friction lock to retain cartridge.

D *Rod Wiper* — Homogeneous lip type located well forward to prevent accumulation of dirt in pocket. Metallic scraper (AN approved) available and interchangeable with wiper

E *Pilot* — O.D. of cartridge serves as pilot for cylinders mounted on rod end.

O-M Series TH High Pressure Hydraulic (oil) Cylinders—conservatively rated at 2000 P.S.I.—are available in bore sizes 1½ to 8-inch inclusive. Descriptive drawings of cylinder, mounts, mounting brackets and capacity chart are included in the new O-M Bulletin 105. Mail coupon for your FREE copy today.

ORTMAN-MILLER MACHINE CO.
7 143rd Street, Hammond, Ind.

☐ Have representative call ☐ Send Bulletin 105

Name_____ Position_____

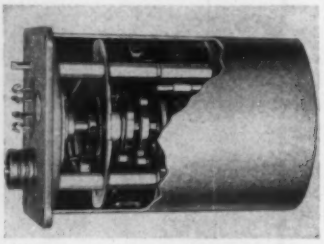
Company_____

Address_____

City_____ Zone_____ State_____

Circle 485 on page 19

New Parts



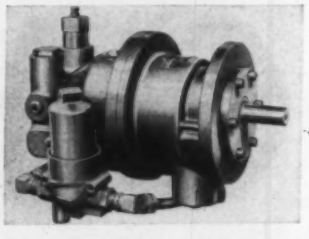
applications, a permanent-magnet type motor or a governor-controlled motor can be used, depending on accuracy requirements. **Eagle Signal Corp.**, Industrial Div., 202 20th St., Moline, Ill.

Circle 706 on page 19

Constant-Displacement Pump

for heavy-duty use at pressures to 5000 psi

Designed for heavy-duty, continuous 3000 to 5000-psi operations requiring 3 to 10 hp, this constant displacement pump is for use on machinery involving high static loads over long periods under adverse conditions. Capacities at 3000 psi range from 1 to 5 gpm, depending on size and rpm of driving motor. Pump is equipped with a purolator-type micronic filter which provides complete filtration and cleaning of the hydraulic fluid before entrance to the high pressure axial piston end, and continues on to the operating cylinder or accumulator. Complete range of mountings is available. **Oilgear Co.**, 1560 W. Pierce St., Milwaukee 4,



Circle 707 on page 19

Circuit Breakers

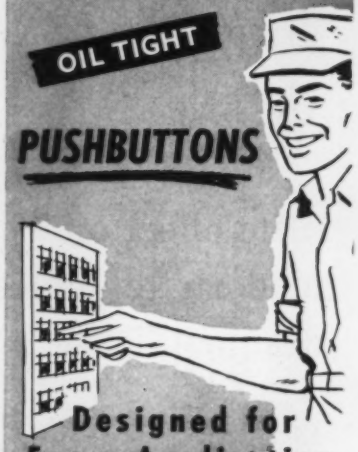
for lighting and power circuits from 15 to 50 amp

TQL 240-v, 2 and 3-pole plug-in circuit breakers are for applications on lighting and power cir-

NEW FURNAS ELECTRIC

OIL TIGHT

PUSHBUTTONS

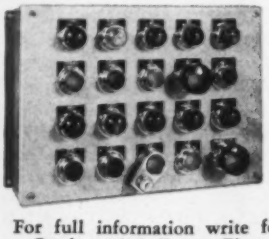


Designed for Every Application

Now for the first time, because of standardization and interchangeability, more combinations of Oil Tight push buttons are available with fewer parts. As a result, Furnas Electric design and research again lead the field, this time with the finest oil tight push buttons available.

When you specify Furnas Electric, you get one standard contact block. No rights or lefts—no special units for horizontal or vertical mounting.

Accessories (key lock, mushroom head or lever) are mounted directly on all standard operators. Operators need not be modified or removed from panels.



For full information write for Catalog 5606, Furnas Electric Company, 1045 McKee Street, Batavia, Illinois.

FURNAS 25TH YEAR

A17

FURNAS ELECTRIC COMPANY

BATAVIA, ILLINOIS

Sales Representatives in All Principal Cities

Circle 486 on page 19

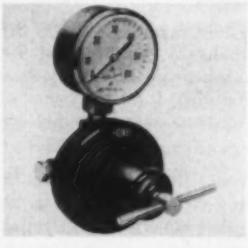
cuits from 15 to 50 amp. Breakers, which utilize standard 1-in. TQL modulus, plug into G-E three-phase service-entrance load centers and lighting panelboards. **General Electric Co.**, Circuit Protective Devices Dept., Plainville, Conn.

Circle 708 on page 19

Pressure Regulator

for flow rate to 250 cfh

Series 660 line pressure regulator has a built-in pressure-relief mechanism which automatically relieves build-up of back pressure on delivery side that exceeds set delivery pressure. Series consists of



four styles with delivery pressure ranges of 0-40 or 0-150 psi and flow rates up to 2500 cfh. All styles have an O-ring seat that provides absolute shutoff. They are available in either line or angle pattern inlet-to-outlet conections. **Hoke Inc.**, 191 S. Dean St., Englewood, N. J.

Circle 709 on page 19

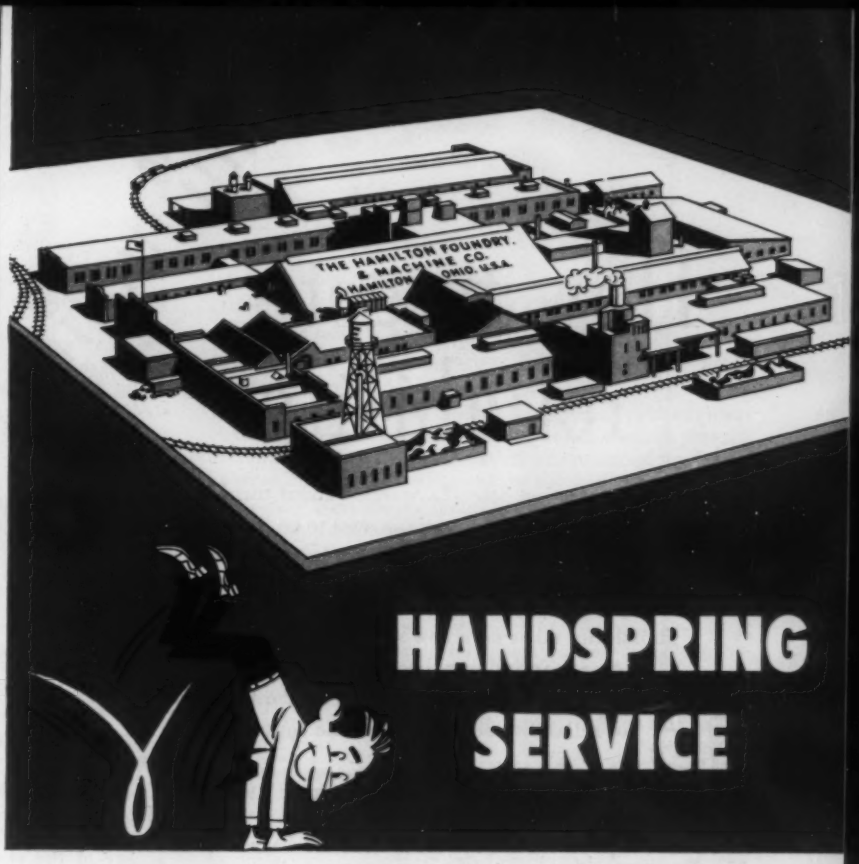
Heating-Element Wire

in widths from 1/8 to 3 in.

Flat, sinuated heating element wire provides a flexible, efficient heat-producing medium adaptable to electric heating problems where

(*Continued on Page* 154)

Circle 487 on page 19→



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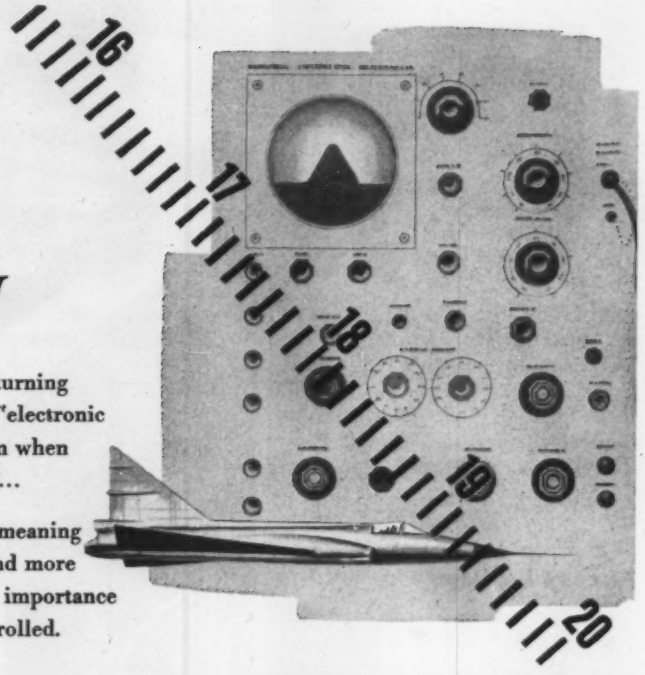
SECOND OF A SERIES

How to get reliability



Got the automation jitters?...worried about turning complex manufacturing operations over to an "electronic brain"?...worried about what can happen when one component in the control system fails?...

Reliability takes on a new and different meaning as American industry becomes more and more automated. Here are a few thoughts on the importance of reliability and how it can be controlled.

All of us are going to have to pay more attention to "reliability."

We'll have to pay more attention to individual "devices" within a system.

We'll have to guard ourselves carefully when we design the entire system.

The industrial pendulum is swinging more and more toward automatic controls, servo-mechanisms, computers, and automatic "watchers." As it does, the reliability factor becomes more and more important. Let's see why. For example, you probably have three radios at home. If one fails because a soldered joint comes apart, your home life is probably not disrupted to any alarming degree. But... consider the automatically controlled steel mill. One soldered joint failing, unless all controls are installed in duplicate (which is expensive) could tie up the entire production process for valuable minutes, if the maintenance crew has second sight. For hours, if automatic trouble-indicating and locating systems are not installed (and these are expensive, too). Last, but not least, lend a thought to the dependence of guided missiles and man-made satellites upon the reliability of electronic circuits and components. So... let's start to examine "reliability." Let's begin by looking at this definition which is currently popular in the technical field:

The reliability of a particular component or system of components is the probability that it will do what it is supposed to do under operating conditions for a specified operating time.

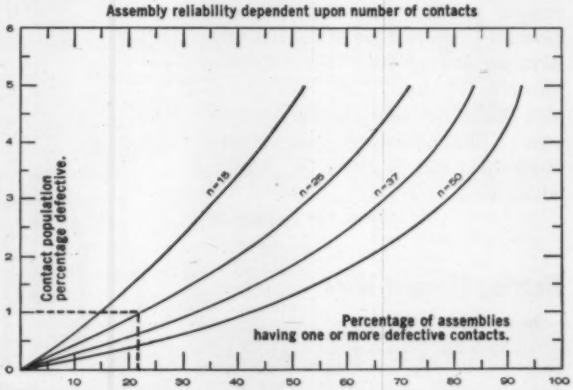
Now... this is a relatively well-accepted definition, and it offers the key to the problem of coping with failure control. Take the word "probability" in this definition. Let's discuss its implication.

Many of today's systems, simple or complex, are a chain of components. So picture a system as a chain with its successive links. In the field of statistics the over-all reliability of the chain is the mathematical product of the reliabilities of the individual links...

Overall Reliability, $R_o = r_1 \times r_2 \times r_3 \ldots r_n$

Now, let's consider a system made up of 100 different components, each of which has a reliability of 99%. In applying the formula, multiplication of .99 by itself 100 times gives an over-all reliability for the system of only 36.5%. Two out of three systems you have put together will probably fail!

Cannon becomes involved with this problem because our main business is making electric connectors. So, let's look at the following chart that covers contact reliabilities and reliability of the assembly in which they are mounted.



This chart illustrates the reliability of four connectors having 15, 25, 37 and 50 contacts respectively. As an example, assume that the contacts have a contact population of 1% defective (1 in 100 defective... this percentage is considered a fairly high standard in most fields). On the 15-contact assembly, we find from our chart that 14% of the connector assemblies would have one or more defective contacts! With 25 contacts, 22% would have one or more defective contacts. With 50 contacts, 41½%... is your hair starting to curl? Obviously, a 99% contact reliability standard for guided missile components is absolutely unacceptable. And, in between the simplest system and that of a guided missile, are hundreds of assemblies and systems whose reliability factors must be analyzed with utmost care.

But all is not lost! There's another side to the picture. With proper care, analysis, and control, our Cannon organization has actually achieved, in special "missile quality" contacts, a known level of only 2.85×10^{-3}% defective... only 1 part in 35,000! Naturally, we don't achieve that with all our contacts... but we do try to design and manufacture the utmost in reliability required for specific applications.

We have pictured this chart to show the direction we must all take, whether we're talking about connectors, other components, or systems. It boils down to two steps...

* The number (n) of components must be kept low ... *simplicity*.
* The level of component reliability must constantly be improved ... *hard work for all of us.*

Now... if we refer to our reliability definition on the previous page we note the phrase "do what it is supposed to do." So be sure *you* define these objectives for your component assembly, or system... failure to do so carefully can cause undue failure or the expenditure of unnecessary dollars for needless, excessively-reliable parts or design.

Further on in the same definition, we note the words "operating conditions." This brings up many new points for consideration. Here we are concerned with such things as temperature, pressure, humidity, corrosive atmosphere, stray electric and magnetic fields, low and high frequency noise, shock and vibration. Do your design standards need upgrading? Are your components designed and then tested to meet the operating conditions you specify... or are they designed to meet "average" conditions? Are you using adequate "safety factors"?

In a simple component, manufacturers have always looked for, recognized, and corrected faults when they occurred. We use component quality control to achieve and maintain Cannon's world famous product quality. But in complex systems such component quality control is not enough. Actually ...

Reliability control over the system is needed. It should be all-encompassing. When you get right down to it, *reliability* is the product of procedures, equipment, and people... in the design, manufacture, testing, control of quality, transportation, and use of products or systems.

Do you have a reliability control system?

Here are a few of the steps that are needed to get a reliability control system operating:

1. Determine Your Requirements. Specify the environment, operating time, performance limits, and the percent of reliability required. Allow an adequate safety factor keeping in mind the end use of the finished product.

2. Collect Reliability Data. Set up facilities for the continuous accumulation of data on component or system failures and their causes.

3. Establish quality control and test procedures which show high degree of correlation with end-use conditions.

4. Analyze. Determine if reliability requirements are being met. Establish the most important causes of failure by analyzing the data you collect.

5. Improve. Take action to eliminate the most important defects or causes of failure. Reduce the failure rate to the required level.

6. Maintain Continuous Vigilance. You have emphasized system design... you have used statistical analysis of failures... now exert continuous and critical control to be sure your "improvements" actually improve reliability. Examine new and unforeseen failure sources. Review and modify your requirements with changing conditions.

*

We at Cannon Electric are proud of our historical emphasis on quality and reliability. Since 1915 we have adhered to a design philosophy embracing the highest quality and reliability in each and every Cannon Plug for the specific application for which it is to be used. *If we can't design to that principle, we don't make it!* In manufacture, we are proud of our know-how in depth, proud of our fine quality control systems, proud of our personnel and proud of our reliability control group.

Whenever *you* have an electric connector reliability problem... in design, engineering, production, or prototype phases... we would appreciate the opportunity of discussing it with you.

Cordially,

Robert J. Cannon *President*

CANNON ELECTRIC COMPANY
3208 Humboldt St., Los Angeles 31, California

CANNON PLUGS

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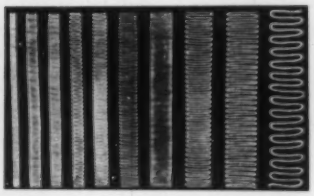
THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

New Parts

(*Continued from Page* 151)

thin wall, pliant construction is desirable, such as in electric blankets, heating pads, electric cooking devices. It can be imbedded in molded or cast plastics or sandwiched between asbestos, mica or other insulating materials. Ele-

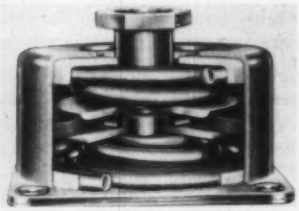


ment has maximum radiation surface exposure, promoting fast, efficient heat transfer and operation at high temperatures. Wire is preformed to specification in width, length, turns per inch and type and gage of wire. It is wound on spools or supplied in cut lengths. Width can be made from $\frac{1}{8}$ to 3 in., governed by wire gage and ability to handle after sinuation. **Syntron Co.**, 260 Lexington Ave., Homer City, Pa.

Circle 710 on page 19

All-Angle Mount

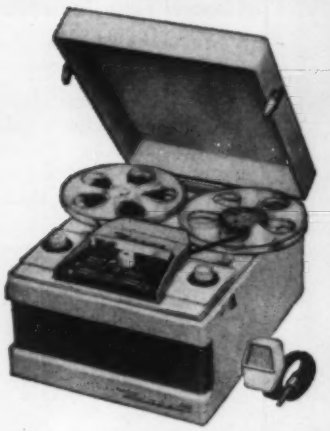
for jet and missile applications



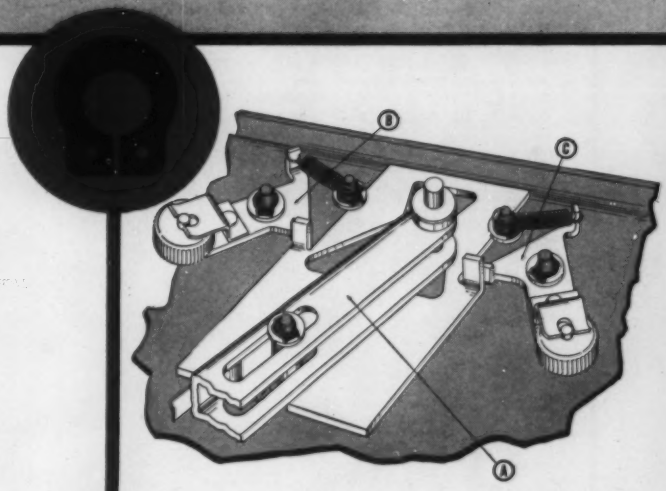
B-64 All-Angl mount, with maximum load ratings up to 40 lb per mount, protects heavy electronic equipment against severe vibration in high-performance jets and missiles. Unit is dimensionally interchangeable with standard MIL-size 2 mounts. The mount gives continuing isolation through all flight attitudes. Isolators are designed to mount equipment at a natural frequency of 15 to 30 cps or higher. High degree of damping keeps transmissibility at resonance below 3. Mount shows negligible change in performance at temperature range from −65 to 120 C and is

Circle 489 on page 19

Waldes Truarc grip rings used on die-cast studs eliminate threading, tapping, other costly machining



Mark Simpson Manufacturing Co., Long Island City, N. Y., uses Waldes Truarc series 5555 Grip Rings to secure parts to studs of the zinc die-cast base of its "Masco 500" portable tape recorder.
The rings—which need no grooves—replace nuts, screws, cotter pins and other types of fastening devices which require threading, tapping, drilling and other expensive machining operations. Because a single cracked or broken stud would render the entire cast base useless—and with it, all assembly completed to that point—the rings also eliminate extremely costly rejects.



Pivot Assembly of shift lever (A) is secured by a single Waldes Truarc Grip Ring and washer. Because the washer must be installed over the shift level in a sliding fit, critical tolerances would have to be maintained if a screw or cotter pin were used. The Truarc Grip Ring eliminates that problem: it requires no groove and may be seated over the washer at any point on the stud, automatically compensating for accumulated tolerances in the parts. BRAKE ASSEMBLIES (B and C) use Grip Rings to secure the brake wheel and spring subassemblies. Here again problems of critical tolerances are avoided and expensive rejects eliminated.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

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Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
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MD039

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,428; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

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Circle 491 on page 19

New Parts

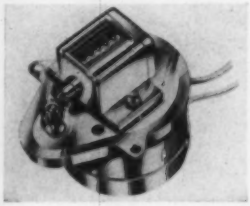
unaffected by salt spray, humidity, sand and dust environments of MIL-E-5272A. **Barry Controls Inc.**, 822 Pleasant St., Watertown 72, Mass.

Circle 711 on page 19

Elapsed-Time Indicators

are available in a wide variety of ranges

Series 7500 dc-unit elapsed-time indicator employs standard or chronometrically governed dc motor. Series 12500 ac unit has synchronous 50 or 60-cycle motor

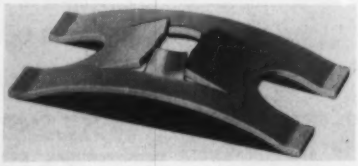


and Series 24200 has 400-cycle synchronous motor. Units are supplied with 5-digit counters. Wide variety of ranges and motor types is available, as are reset units and hermetically sealed housings. Indicators provide daily and total running time record for any electrical or electronic equipment. Very low power consumption makes remote location practical. **A. W. Haydon Co.**, Waterbury, Conn.

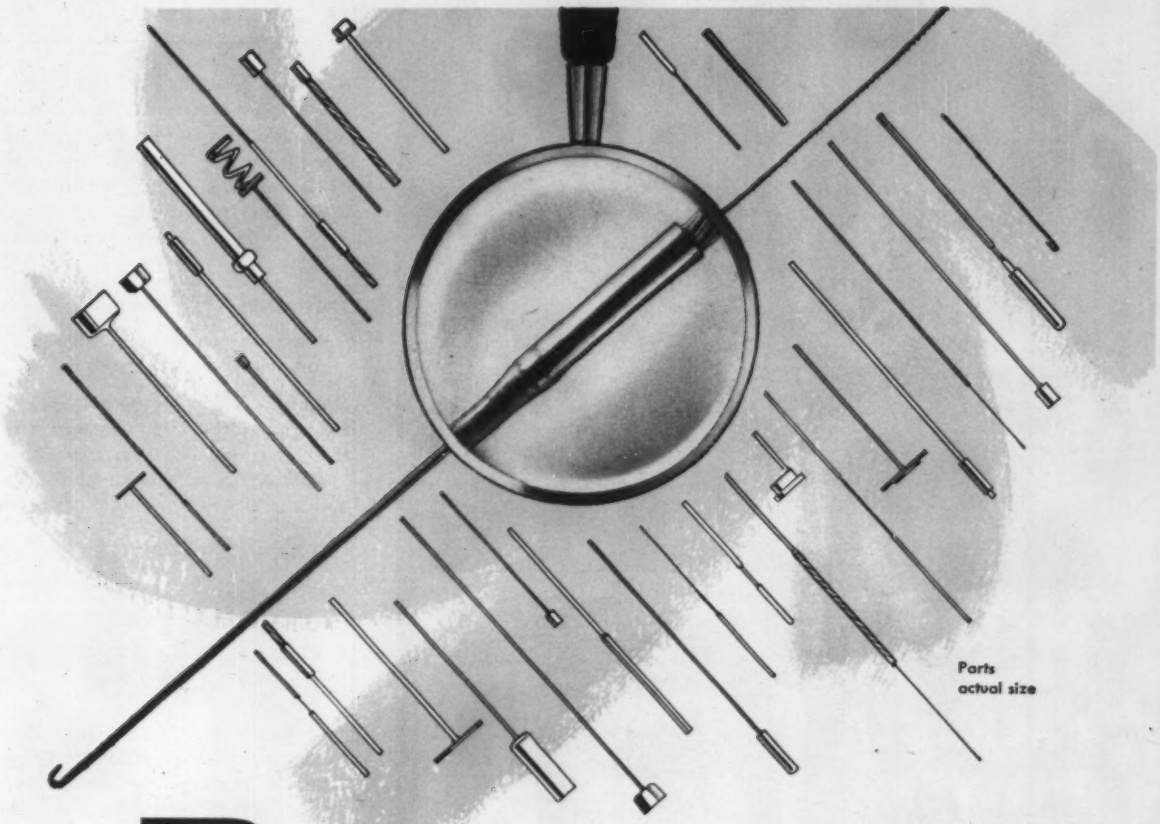
Circle 712 on page 19

Stainless Fasteners

have excellent corrosion resistance



Type H Pushnut fasteners for unthreaded studs of die-cast nameplates, medallions, grilles and ornaments are available in 410 stainless bright hardened steel for applications requiring a high degree of corrosion-resistance. Design incorporates: Four gripping teeth which hold tight on hard or slippery plated studs; long spring arch that compensates for wear on parts; turned-up ends that slide



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We will be glad to quote prices on a production run for your special components.

Sylvania's Parts Division offers complete facilities for custom-molded plastic parts . . . metal stampings . . . plated or clad specialty wire . . . special electronic components. For complete details of these services, write for free copy of: "Portfolio of 4-way Service to Designers."

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Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

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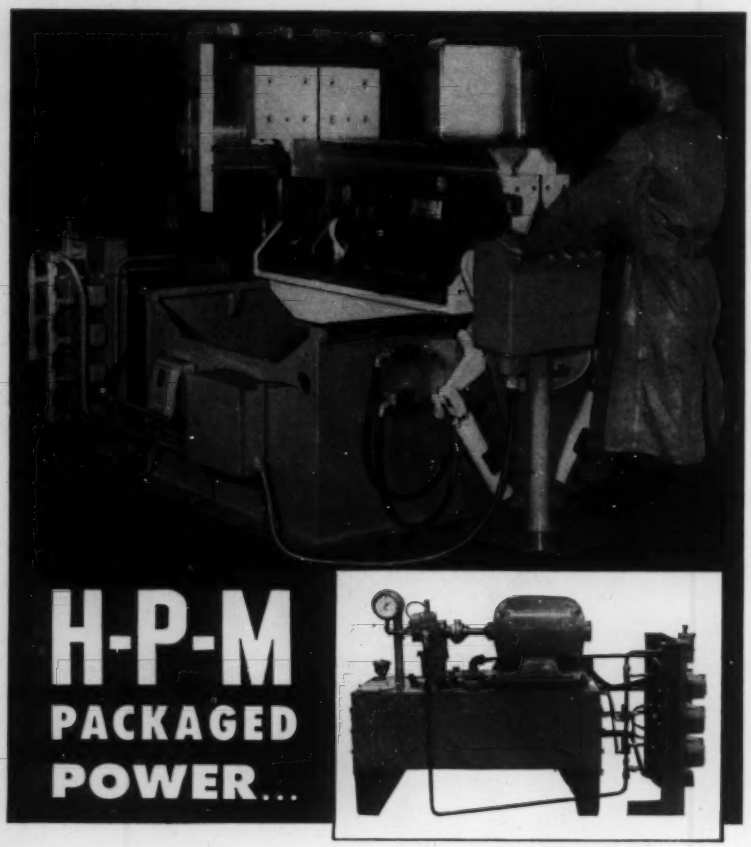
SPECIAL WIRE | METAL STAMPINGS | MOLDED PLASTIC | ELECTRONIC COMPONENTS

4-way service from one source

Circle 492 on page 19



as used by Struthers Wells

Struthers Wells Corporation, Titusville, Pennsylvania, manufacturers of quality bending machines, specify dependable H-P-M hydraulics for the smooth, positive action so important for metal bending operations. Here are the reasons: convenient off-the-floor design, easy access to all elements of the unit, compact solenoid operated valve panel system, easy-to-reach electric pushbutton controls and most important—dependable, job proved H-P-M components that provide solid satisfaction through years of service. You can rely on H-P-M—and recommend them for your OEM equipment. Send for complete catalog information, today.

HPM

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New Parts

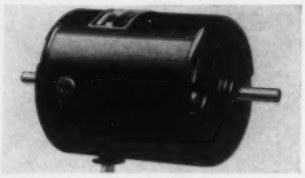
smoothly and prevent damage to seating surface; and fast assembly with hand or power tool applicators. Sizes are available for 1/16, 3/32 and ⅛-in. studs. **Palnut Co.**, Glen Rd., Mountainside, N. J.

Circle 713 on page 19

Fractional-HP Motors

miniature units have wide range of characteristics

Model M-20 and M-100 motors feature extra strong castings for their size and are available either ventilated or enclosed and with ball or sleeve bearings. Motors

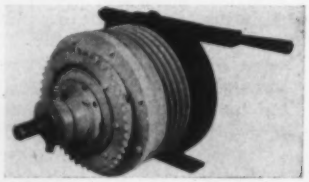


may be equipped with any of a wide variety of gear units. Windings are universal or shunt; permanent magnet motors are also available (dc shunt). Voltage is 6 to 220 ac/dc or dc shunt. Max hp is 1/30 continuous; shaft diam is 5/16-in. max. **Rae Motor Corp.**, 2009 Kawaunee St., Racine, Wis.

Circle 714 on page 19

Reduction Pulley

for two-speed operation at ratios to 8000:1



Reduction pulley, with internal planetary gearing to provide speed reductions up to 8000:1, is available for two-speed operation and can be supplied for V-belt drive or adapted for chain or gear drive, as shown. Two clutches are provided: Standard disk clutch locks housing direct to the shaft and gives normal V-belt reduction; drum-type clutch, built into the pulley and operating through internal gearing, permits larger reductions. Use of two built-in drum-

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Circle 494 on page 19

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A call, telegram or letter to your nearest Continental office will bring a representative to discuss your problem.

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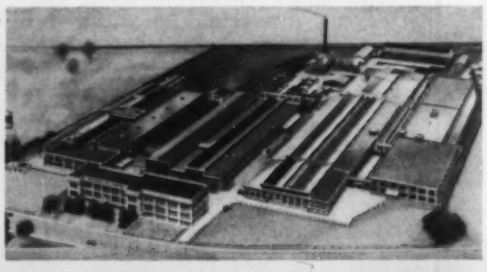
Our 10-acre Birmingham plant contains a Meehanite foundry, the South's largest modernly equipped machine shop, a complete fabricating and assembly plant. All staffed and readily available for your use.



CG-5711

INDUSTRIAL DIVISION
CONTINENTAL GIN COMPANY
BIRMINGHAM, ALABAMA

CGC ATLANTA CLEVELAND DALLAS KNOXVILLE MEMPHIS MOBILE NEW YORK 17

New Parts

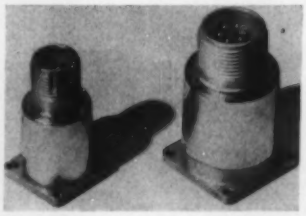
type clutches provides two internally reduced speeds which can be in the same direction or one forward and one reverse. Unit can also be equipped with electrical, mechanical or pneumatic clutches which can be remotely controlled. Overload release is available. **Hart Reduction Pulley Co.**, 426 W. Main St., Waukesha, Wis.

Circle 715 on page 19

Indicator Switch

mechanically actuated unit shows position of valves

Capswitch position indicator which signals when a valve has completed its closing or opening cycle is for use in aircraft and guided missiles. It is also used on propellant valves for malfunction analysis,



and is adaptable to any type of control where repeatability within ± 0.001-in. is desired. Two models are available: An SPDT type which weighs 0.095-lb and a DPDT type weighing 0.19-lb. Both are completely sealed in epoxy resins. Entire mechanism is encased in a steel sheel. Indicator is mechanically actuated by a valve-stem coupled plunger, which closes and/or opens control circuits. **Robertshaw-Fulton Controls Co.**, Bridgeport Thermostat Div., Milford, Conn.

Circle 716 on page 19

Air Control Valves

in seven valve bodies

Starline series of air control valves incorporates five new pilot heads interchangeable on 7 valve bodies to provide 35 model combinations. Valves provide long life and modular construction for flexibility in applications. Seven valve bodies include: straight way, normally open and normally closed; three way, open and closed; (in-line series); three way, normally

20 Typical Case Histories...

How to Cut Production Costs

with Norgren Spray-Lube

- **Faster Tapping and Metal Cutting**
- **Longer Tap, Tool and Die Life**
- **Cleaner Cuts—Better Workmanship**

BETTER LUBRICATION — EXACTLY WHERE NEEDED — Norgren Spray-Lube applies an airborne spray of cutting liquid directly to the cutting area. The larger fluid surface area of the spray and the expansion of the compressed air dissipate heat quicker, more thoroughly.

Here are the results of 20 actual installations showing a few of the many possible ways Norgren Spray-Lube can cut maintenance costs and boost production in your plant.

Milling a 2" wide slot 4" deep in steel weldments, Spray-Lube increased feed from 2" to 9" per minute.

Cutting stainless steel shafts on automatic lathe, Spray-Lube doubled tool life, improved quality of product, eliminated contamination of bearing and gear oil.

Working and finishing speed doubled working aluminum on vertical turret lathe. Cutting speed upped from 45 to 75 rpm. Depth of cut increased. Welding of chips to tool and galling of work pieces ended.

Chain life doubled on degreaser by automatic, continuous lubrication with Spray-Lube. Chains run smoothly, quietly; last longer.

SPRAY-LUBE lubricates 97 taps during single machine cycle. Taps are cleaner and last longer. Production time is saved.

Increased saw blade life in sawing copper tubing has resulted through lubrication with Spray-Lube. Also resulted in cleaner cut, easier chip removal and elimination of flying chips.

Surface grinding stainless steel parts with aid of Spray-Lube has provided good results.

Saw arbors on lumber edgers lubricated by Spray-Lube. Also dissolves pitch and gum on arbor. Lubricant saving alone returned Spray-Lube equipment and installation cost in two months.

Punch press output up 15% in stamping circular plates from 28-gauge cold rolled steel. Die life increased by 100% — ended messy manual lubrication.

Tap breakage practically eliminated on multiple spindle machine. Also ends down-time due to clogging of coolant return lines.

Trimming die on 50 ton press lubricated by Spray-Lube, eliminating sticking in the stripper.

Drilling speed increased 38%, tool life doubled, in drilling 3/8" holes in 1½" steel plate. Paid for itself in one month in machine cleaning time alone.

Deep drilling is lubricated by spraying coolant through hollow drills with Spray-Lube. Excellent results.

SPRAY-LUBE on gear hobbers has increased tool life, reduced tool maintenance and resulted in lubricant savings of $250 a year per machine.

Copper tubing on bending machine is lubricated by Spray-Lube, assuring proper drawing of tube wall. Eliminates hand dipping operation.

Hot forming die is cooled faster, lubricated better, when sprayed with graphite coolant by Spray-Lube.

In cutting 6" aluminum slabs, Spray-Lube increased saw feed to 5 fpm. Ended overheating of saw blade, fusion of chips and galling of slabs.

Tapping output increased 30% Eliminated draining and wiping of coolant-flooded parts. Improved safety and working conditions.

Deep drawing large caliber shell casings. Dies and work pieces are lubricated with Spray-Lube, providing better, more thorough lubrication.

Dust conditions were eliminated by Spray-Lube on sanding belt used for polishing turbine blades.

For complete information about Norgren Spray-Lube . . . call your nearby Norgren Representative listed in the telephone directory—or WRITE FACTORY FOR BROCHURE 537A.

C. A. NORGREN CO.

3442 South Elati Street Englewood, Colorado

Circle 496 on page 19

SIMPLIFY MACHINE DESIGN WITH THIS *Different* AIR CYLINDER

Save design time — save production costs. Eliminate cams, levers, gearing, linkages or other mechanical means for performing push, pull or lift motions. Design with air in mind.

The Bellows Air Motor is a complete electrically-controlled air cylinder power unit with directional valve and speed controls built in. It requires only one air connection which can be made with flexible hose. Compact, space saving, it fits well into crowded quarters or on moving machine elements. It is fast, responds to a starting impulse instantly. It is easily interlocked and synchronized with related machine movements. Its quality and reliability has been proven in more than quarter of a million installations.

The range of work it can do is limited only by the imagination of the design engineer.

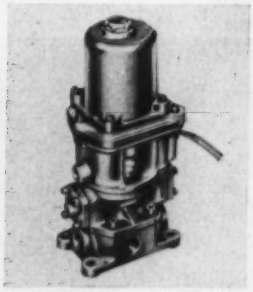
Send for this free booklet

Here in these quick reading pages is the full story of The Bellows Air Motor — what it is doing for others, what it can do for you. Address Dept. MD357 The Bellows Co., Akron 9, Ohio. Ask for Bulletin BM-25. In Canada, write Bellows Pneumatic Devices of Canada, Ltd., Toronto, Ontario.

765-B

The Bellows Co.
AKRON 9, OHIO

Circle 497 on page 19



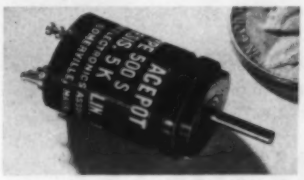
open and normally closed; and four way (base-mounted series). Of corrosion-resistant materials, the valves are compactly designed and lighter than previous models. **Ross Operating Valve Co.**, 120 E. Golden Gate Ave., Detroit 3, Mich.

Circle 717 on page 19

Subminiature Potentiometer

has minimum starting and running torque

Acepot jewel bearing, subminiature precision wire-wound potentiometer has applications in sensitive instruments, servos, computers or selsyns where minimum starting and running torque is required. Jewel bearings provide extremely low



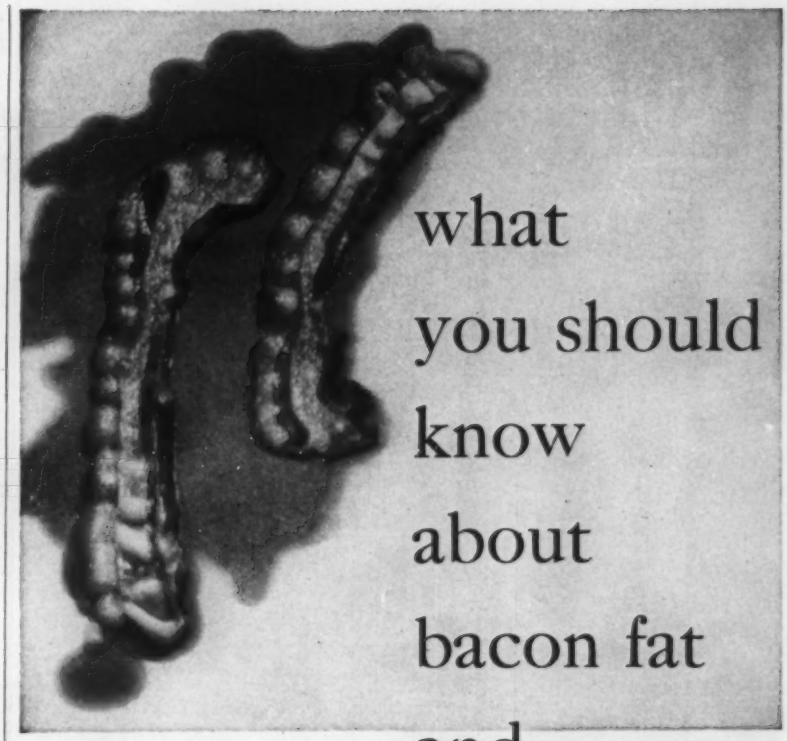
torque and seal against abrasive dust or other foreign materials. Specifications include: torque, 0.01 oz-in.; size ½ × ½-in.; weight, ¼-oz; resistance range, 10 ohms to 250K standard; linearity, ±0.3 per cent; power rating, 2 w for 60 C rise; and temperature range, −55 to 150 C. Unit meets applicable portions of JAN specifications and MIL-E-5272A standards. **Ace Electronics Associates Inc.**, 103 Dover St., Somerville 44, Mass.

Circle 718 on page 19

Plastic Bobbins

for custom designs

Complete line of custom-formed cylindrical bobbins can be made of epoxy resin, nylon, Teflon or



what you should know about bacon fat and Albanene

Here's the buying information you should have to get the *best* value when you buy tracing paper.

1. **The usual way** of "transparentizing" tracing papers is with waxes or mineral oils—much the way bacon fat makes a paper towel transparent. Eventually, these oily fluids "leak" out—leaving the paper opaque and useless for reproductions.

   Result: Valuable drawings on ordinary tracing papers eventually become yellow or brittle—lose their reproduction qualities. And, these days, replacements often cost twice as much as the originals.

2. **The K & E way**—Albanene tracing paper is made transparent with an inert synthetic resin which is chemically stable . . . can't leak out—ever!

   Result: Albanene stays transparent . . . stays strong . . . protects every nickel you invest in time and talent working on it.

   Important: During manufacture, constant testing *guarantees* uniformity as well as pencil taking and erasing qualities. The very qualities that have made Albanene—America's best selling tracing paper.

Try Albanene Today . . . it's available in 3 weights and in rolls, sheets or pads. Try it now . . . it's the best value you can buy!

89 YEARS OF LEADERSHIP

In equipment and materials for drafting, surveying, reproduction and optical tooling . . . in slide rules and measuring tapes.

K+E KEUFFEL & ESSER CO.

NEW YORK • HOBOKEN, N. J. • Detroit • Chicago • St. Louis • Dallas • San Francisco • Los Angeles
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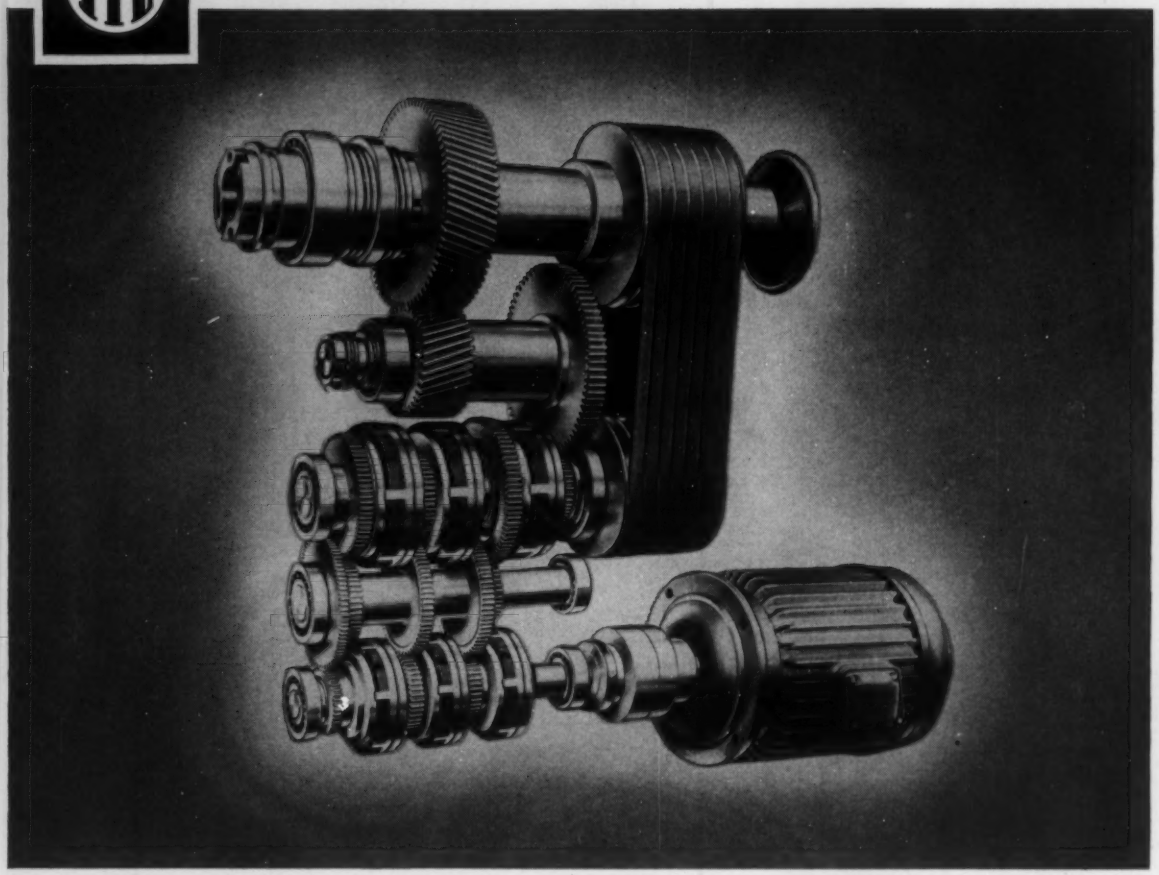
Circle 498 on page 19

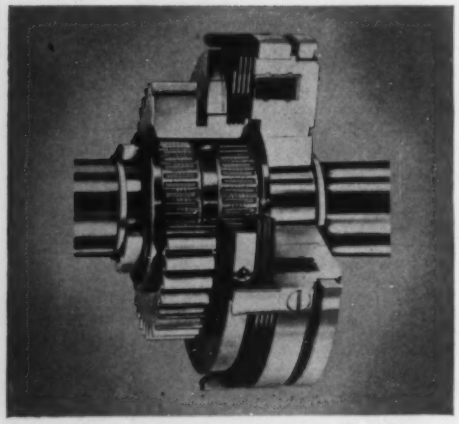
ELECTRO CLUTCHES



Milling machine drive using six I-T-E Electro Clutches and providing a total of nine speeds and braking. High-low range is attained by use of one slide gear.

CHANGE SPEEDS OR FEEDS ON THE FLY

by push button, limit switch, relay



Type H design showing unit construction.

FEATURES:

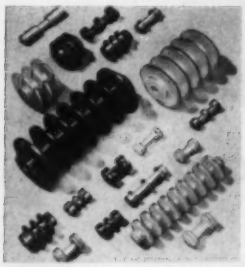
• No adjustments required for wear • Simply and easily installed
• Positive operation • No complicated wiring • Fast response
• Cushioned operation—no shock loading of gears or shafts

Tapered torque ratings from 3.2 to 13,000 lb.-ft. make possible the selection of the correct I-T-E Electro Clutch for the application. For complete data, write for Bulletin 5306.

I-T-E Circuit Breaker Company, Transformer & Rectifier Division, 19th & Hamilton Sts., Phila. 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY
Transformer & Rectifier Division

Circle 499 on page 19



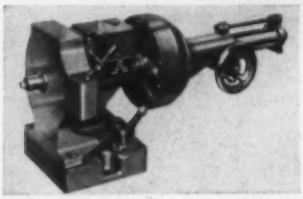
other plastics. Bobbins are formed to any desired cylindrical shape within size range of ⅛ to ⅞-in. diam and lengths up to 7 in. No molds are necessary in the process, thus eliminating mold costs and lead time. **Orange Products Inc.**, 554 Mitchell St., Orange, N. J.

Circle 719 on page 19

Boring Head

high-precision unit holds 0.0003-in. tolerances

Hydro-Borer model C-4 precision boring head produces tolerances of ±0.0003-in. and finishes to 30 mu in. Unit may be mounted on any type base. Fixtures can be mounted



to base or directly to head. Automatic trip and spindle return are optional. Spindle is 1¼ in. diam with No. 2 Morse taper. Hydraulic feed has range of either 0.003 to 0.004-in. or 0.0035 to 0.007-in. in either direction. **Greenlee Bros. & Co.**, Rockford, Ill.

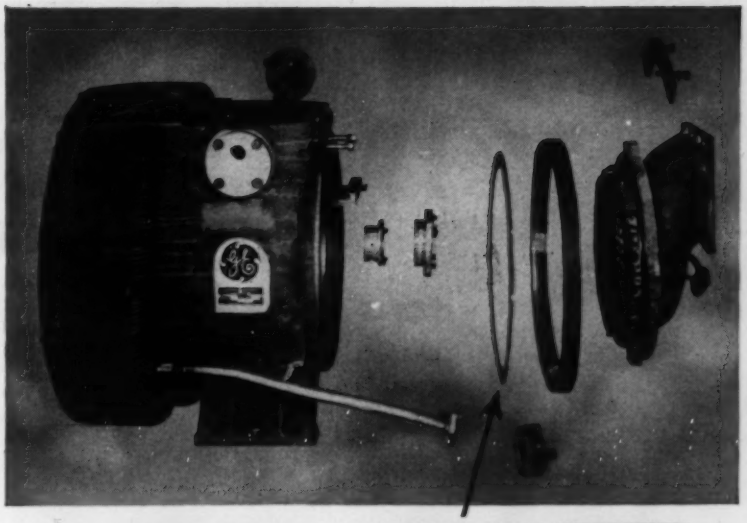
Circle 720 on page 19

Aluminum Connectors

for wide range of cable sizes

Six heavy-duty aluminum U-bolt clamps, designated Series 580, employ universal, parallel spacer grooves. They can be used on ACSR from No. 2 to 715.5 MCM and also will handle sizes No. 2 to 800 MCM stranded aluminum conductor. Length of clamps, number of bolts

(*Continued on Page* 168)



LAMINUM® adjustable SHIMS

cut assembly costs on turbo-supercharger for diesel engines

THIS is only one from thousands of laminated shim applications throughout all industry. Yet the reason for using laminated shims and the gains resulting are typical. This shim sets the clearance between the nozzle and buckets on the General Electric RD3C turbo-supercharger. Shimming is essential because of the accumulation of tolerances. The laminated shim can be adjusted quickly merely by peeling—and after peeling is always precisely uniform in thickness from end to end and side to side. Peeling is far easier and faster than precision grinding which would prove quite costly on these extremely large shims.

Whenever you need shims, call the Laminated Shim Company *first*...for fast, complete service. We manufacture shims in aluminum, brass, steel—small as a fingernail and large enough for locomotives...laminated, spot-soldered or looseleaf. Produced to your own precise blueprint specifications.

For further information and free booklet telling all about laminated shims and how they're used, please write. No cost or obligation, of course. Write today!

The name Laminum is registered with U. S. Patent Office

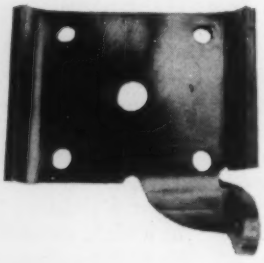
1203 UNION STREET, GLENBROOK, CONN.

LAMINATED SHIMS OF LAMINUM® AVAILABLE IN BRASS • STEEL • STAINLESS STEEL • ALUMINUM

Circle 500 on page 19

Why this particular rear spring bracket becomes important to all manufacturers

In itself, the ArmaSteel spring bracket described here is of small interest except to the automobile manufacturer for whom we made this study. But this bracket becomes significant as a typical example of what is being done—what can be done—here at Central Foundry Division to increase strength, reduce weight, and reduce the cost of many types of parts by means of relatively new stress analysis testing techniques.

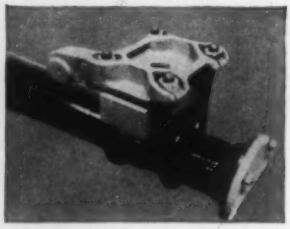


1

The steel stamping for the rear spring bracket (clip pad) of a popular passenger car. ● Made from .438 stock, S.A.E. #1015 steel, the part weighs 4.2 pounds. From this, a casting is to be evolved with these specifications: 800 pounds maximum push or pull load on shock absorber ear, 75 foot-pounds assembly torque load on each U-bolt lock nut.

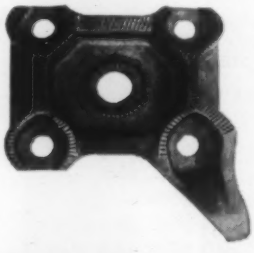
2

Cast design no. 1 is created. ● Already slightly lighter in weight (4 pounds) than its stamped counterpart, this version is submitted for stress analysis. Preliminary tests indicate this casting is overdesigned. The unnecessary ribs can be eliminated, shock absorber ear can be tapered, and a second, lighter design is evolved, weighing only 3.25 pounds.



3

Testing. ● Using a production axle, each casting design is fastened on over rubber pads. The insertion of a steel block duplicates spring thickness. Production U-bolts and lock nuts are also used to duplicate actual loading conditions and torque characteristics.

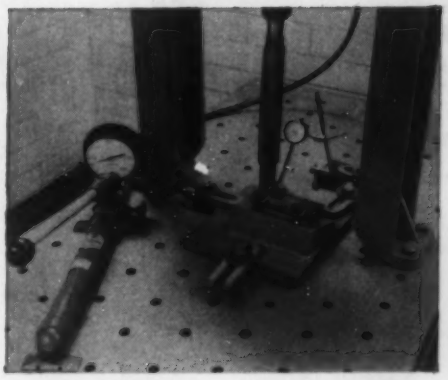


4

The stress pattern on casting is established. ● Using brittle lacquer, the areas of highest stress concentration are determined so that casting weight can be further reduced without reducing the strength of the part.

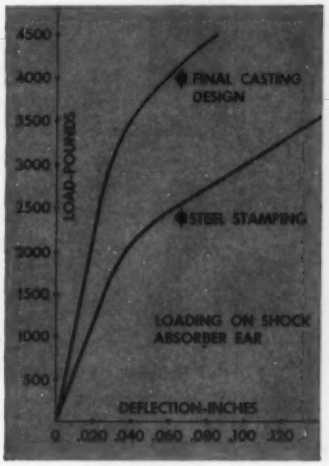
5

The 4th and final design. ● Now weighing but 2.90 pounds, the fourth version is fastened to the test device's loading fixture (shown at right) to test the shock absorber ear for deflection and yield points. This revised version proves the value of stress analysis by sustaining nearly 3,000 pounds load (yield point) at less than 0.30 inches deflection—almost 2,200 pounds ABOVE the auto manufacturer's specifications! *Only now* will the tested design be submitted for approval.



6

Testing shock absorber ear on casting for Deflection and Yield Point. ● The casting was fastened to the loading fixture simulating actual loading conditions using rubber pad and steel block, and load increments were applied on the shock absorber ear.



7

Stress analysis helped create a stronger casting design. ● Above graph illustrates the improved strength and rigidity of the casting over the stamping.

8

Even the actual load on U-bolts was determined. ● Strain gauges, as shown above, were fastened to U-bolts, and strain readings were made at required torque. The bracket, as it finally evolved, assured the auto manufacturer that the final design was without inherent weakness.

Just as we helped this manufacturer to produce a better bracket at lower cost so, too, can our research department assist you by means of the latest equipment and processes including stress-analysis, Cobalt 60, Radiography, Spectrochemical analysis and Sonic testing. Brief descriptions of these and many other phases of modern casting methods are contained in the new book, "SHELL CASTING AT CENTRAL FOUNDRY".

Write for free copy of new "Shell Casting" catalog, today.

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION ● SAGINAW, MICHIGAN ● DEPT. 14

Circle 501 on page 19

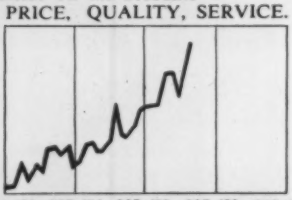
Does VOLKSWAGEN bother Cadillac?

We don't make CADILLAC air cylinders and we don't pretend that we do...

We do claim that we make very good cylinders at very good prices:

BORE	BASIC PRICE	ADD PER " OF STROKE
1⅛"	$15.50	$.35
1½"	$20.50	$.50
2"	$25.50	$.55
2½"	$29.50	$.65
3"	$32.50	$.95
4"	$47.50	$1.20

We furthermore claim that we work hard to ship from stock and our sales chart tells us that we are being successful on all accounts — PRICE, QUALITY, SERVICE.



Besides cylinders, we also make the ALLENAIR line of AIR VALVES, AIR CLAMPS and DIAL FEED TABLES and if we could tell you right here all there is to tell you about what we offer and how those products can increase your PRODUCTION at MINIMUM COST we wouldn't need the $1.25 24-page catalogue that is available for free this month to anyone seriously interested.

THE A. K. ALLEN CO. MD-37
57 Meserole Ave., Brooklyn 22, N. Y.
Name.....
Company.....
Address.....
City.....Zone.....State.....

P.S.—*The cylinder pictured is a Factory Reject. The only rods available are straight ones and made out of #416 Stainless Steel ground and polished stock and repolished after machining. The bearing is nylon.*

The answer to the question on top of this page is: *Not one bit. There is a market for both!*

ALLENAIR **THE A. K. ALLEN CO.**
57 Meserole Ave., B'klyn 22, N. Y.

Circle 502 on page 19

New Parts

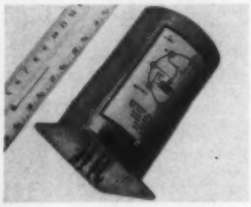
(*Continued from Page* 165)

and bolt sizes depend upon range of conductor size to be accommodated and application. U-bolt portion, flattened to reduce bulk, provides wrap-around strength and even pressure distribution. All-aluminum construction provides resistance to corrosion and long life. Clamps have been tested to 200 F with no significant change in connection resistance. **Aluminum Company of America,** 1501 Alcoa Bldg., Pittsburgh 19, Pa.

Circle 721 on page 19

Time-Delay Switch

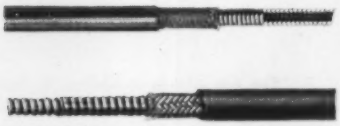
has accuracy of ±5 per cent of total timing cycle



Miniature motorized time delay switch, accommodating up to five single-pole, double-throw switching functions, has a timing accuracy of ±5 per cent of total timing cycle under all conditions. It meets military environmental requirements of MIL-E-5272 and radio noise per MIL-I-6181B if desired. Size is 2 9/16 in. diameter by 4 3/16 in. long on largest units. Normal delays are from 15 to 30 seconds, with instantaneous reset when power is removed. Unit is hermetically sealed, and connecting wires are soldered to terminals extending through a glass back plate. Switch operates at 6 to 50 v dc. Power input is 15 w for the motor, 7 w for clutch. Motor stops automatically at the end of the timing cycle, with switch position maintained by a clutch. Power interruptions during or after timing cycle will re-

(Advertisement)

FLEXIBLE SHAFTING IS DESIGNED TO LAST



Numerous applications of flexible shafting have necessitated the use of many different metals and alloys which make up the flexible cables and casings. In choosing the metals to be used, there are many factors which must be taken into consideration.

For example, a manufacturer may have need for a flexible shaft that must carry a certain load, be acid resistant, and fit a definite type of motor. The wires of the cable and the metals of the casing will then be selected on a basis of strength, flexibility, and their acid resistant properties.

Among the many materials which have been found effective for the cables are phosphor bronze, and monel metal, along with many other types of steel. The casing may be made of many different metals. A metal or fabric covering may be used as a protection from certain acids, water or rust. The metals used are light in weight yet of long life.

Flexible shaft assemblies do the job of transmitting power over, under, and around obstacles efficiently and economically, while at the same time they are designed to add attractiveness to the product.

For full details of why flexible shafts have become an almost common industrial item to the far sighted product designer, write to **F. W. Stewart Corporation,** 4311-13 Ravenswood Ave., Chicago 13, Illinois.

(*Advertisement*)

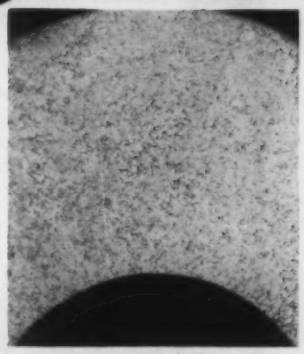
Circle 503 on page 19

Super-Pressure Tubing—Economical and Dependable for pressures as high as 100,000 PSI

Here's how *you* can take the high cost out of high-pressure installations. No more machining and deep-drilling of stainless steel bar—that's old fashioned and expensive. For high-pressure autoclaves and in research labs where pilot equipment for hydrogenation and polymerization processes require high pressures, Superior super-pressure tubing is cutting high costs, helping avoid critical failures and downtime.

Superior super-pressure tubing offers long service life, high fatigue strength, excellent corrosion and chemical resistance. Available in single wall or composite wall (shown above), it is designed to carry internal pressures ranging from 15,000 to 100,000 psi, in OD sizes ranging from .125 in. to .750 in. Primary advantages of single wall tubing are economy and reliable service, plus long life, at recommended maximum working pressure for a given size. Composite wall tubing, used for extra-high pressures, offers the advantages of combining different materials. For example, the inner wall can be highly corrosion resistant, while the outer wall, not exposed to such corrosion, can be of a more economical material. Analyses for Superior super-pressure tubing include stainless steel Types 304, 316, 321 and 347 and AISI 4130 alloy steel.

Why not call on our long practical experience with super-pressure tubing. We can help you with virtually any tubing problem that confronts you. For more super-pressure tubing information, get your free copy of Data Memo 22. Write Superior Tube Company, 2010, Germantown Avenue, Norristown, Pa.



Unretouched photomicrograph shows etched section of Type 304 stainless steel super-pressure tubing at a magnification of 50x. Note smooth, uniform ID and fine grain structure.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010" to ⅝" OD—certain analyses in light walls up to 2½" OD

West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

Circle 504 on page 19

COST

IS A BIGGER WORD THAN EVER

RINGS ROLLED & FLASH-WELDED from a Mill-Rolled Section

SAVED $220.63 EACH

A ring originally designed as a casting weighed 390 lbs. and cost $280.00. Later it was purchased from Amweld, as a rolled and flash-welded ring made from a contoured mill-rolled shape. More than triple savings resulted. Basic cost dropped to $59.37 and weight was reduced to 94.5 lbs. In addition, considerable time and money were saved in the finished machining operation.

Switching to Flash Butt-Welding of Mill-Rolled Sections Slashed Production Cost 76½%

SAVED $103.46 PER RING

Rough rings purchased by a well-known manufacturer of jet aircraft engines weighed 135 lbs. each. Most of this weight was excess metal which had to be machined away. American Welding's Industrial Products Division, working with this company, studied the product and recommended a flash butt-welded ring, formed from a special mill-rolled shape. Adopting this new ring saved 88 lbs. of metal and eliminated much of the machining time required.

American Welding can help cut costs in your plant by suggesting the use of rings rolled and flash welded from mill-rolled or extruded shapes.

THE AMERICAN WELDING & MANUFACTURING CO.
130 Dietz Road • Warren, Ohio

Contact the Industrial Products Division of The American Welding & Manufacturing Company. We will be glad to show you more actual cases of cost savings.

AMERICAN WELDING
The World's Leading Manufacturer of Welded Rings

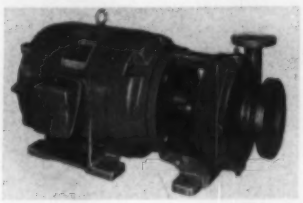
sult in automatic reset. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton, O.

Circle 722 on page 19

Centrifugal Pumps

have capacities to 600 gpm

Standard, close-coupled, centrifugal pumps which handle a wide range of general applications are designated Type GSC. Seven pumps are included with capacities to 600 gpm and dynamic heads to 275 ft. Temperature range of liq-

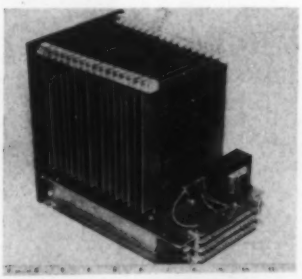


uids accommodated is −40 to 250 F. Units are available bronze fitted, all-iron and all-bronze styles. Construction includes removable back head to permit removal of the impeller without disturbing piping, large cradle opening for free access to stuffing box, and a stuffing box adaptable to packing and mechanical seal. **Dean Brothers Pumps Inc.**, 323 W. 10th St., Indianapolis 7, Ind.

Circle 723 on page 19

Digital Comparator

for use in servo control systems



This digital comparator, designed for use in digital servo-control systems, gives true digital control without the use of counting techniques. In conjunction with 13 or 19-bit shaft-position to digital converter, it provides digital control through conventional servo am-

(*Continued on Page* 174)

Complete NEW Line of "Diamond H" Thermostats (Series 270)

For

- Grease Kettles
- Steam Tables
- Coffee Urns
- Air Conditioning
- Motor Control
- Oil Baths
- Platens
- Range Ovens
- Laboratory Equipment
- Solenoid Control
- And Many Other Applications

"Diamond H" engineering, noted for building better, more dependable performance into smaller space in relays, switches and other electrical and electronic controls, has now developed an entire new line of extremely compact thermostats for a wide variety of applications.

Series 270 thermostats provide accurate calibration, consistent low-differential operation and positive, over-the-center, quick action (to make or to break on rising temperature) in single pole, single throw and double pole, single throw models.

Circuits vary from simple on-off to special selector sequencing to meet special requirements, including single dial, automatic preheat operation for oven models. Temperature ranges are available to suit the application.

Some units may be equipped with terminals for remote pilot light connection; others with terminal clips for direct connection of pilots. Spade terminals simplify wiring.

UL approved standard ratings up to 25 A., 125-250 V., A. C., are available. Horsepower ratings up to 1 h. p., 120-240 V., A. C., special bulb and capillary lengths and sizes, together with special spindle and mounting arrangements, and dials in a choice of colors and marked to suit the customer, may also be obtained.

Descriptive bulletins T270 and T276H are yours on request. "Diamond H" engineers are prepared to work out your specific requirements with you. Tell us your needs.

THE HART MANUFACTURING CO.

118 Bartholomew Ave., Hartford, Conn.

Circle 506 on page 19

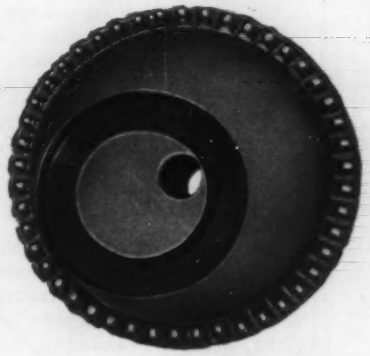
MUELLER BRASS CO. 600 SERIES BRONZE

the main working part in the smooth and OCEAN CITY SPINNING REELS

600 Series gears prove ideal in heavy duty salt water models 300, R300, and 320 in which corrosion resistance and high strength are important.

Other typical "600" applications

FORGED GEAR powerful



The Montague-Ocean City Rod & Reel Co. of Philadelphia is proud of the fact that many fishermen are calling their famous Ocean City "300" series spinning reels "the most dependable spinning reels in America." Such praise justifies the very best components in a product—like the corrosion-resistant Mueller Brass Co. "600" alloy gear. Provides its own shaft and has an integral clutch which takes the driving force from the handle, and incorporates a cam which provides the oscillating motion of the spool for cross-winding the line. Bronze was chosen because of the need for maximum strength, long wear, and because it is such an excellent bearing material. This application dramatically points up the valuable properties of Mueller "600" series alloys.

There are countless applications of Mueller "600" series bearing alloys. Find out how you can utilize one or more of them in YOUR products. Because forgings can be made closer to the finish size in "600" series alloys than can sand castings, there is less waste, greater speed in finishing.

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

- Mueller Brass Co. Forgings Engineering Manual H-58565 ☐
- Tuf Stuf Aluminum Bronze Alloys Engineering Manual H-58563 ☐
- 600 Series Bearing Alloys Engineering Manual FM-3000 ☐
- Copper Base Alloys in Rod Form Engineering Manual FM-3010 ☐

METALS AND ALLOY REVIEW

by FRANK M. LEVY
Vice-President and Director of Research

Recently Ray Engelgau, who heads our statistical quality control procedures, and Amos Armitage from our machining department met in my office and we had a very interesting discussion on our new "S-C" rod. The term "S-C" is derived from the fact that it is produced from billets that are cast semi-continuously. In addition, we use the letters "S-C" to indicate its "super cutting" qualities which is one of the outstanding characteristics of this rod. We have definitely proved these qualities in some very exhaustive tests, one of which I'd like to tell you about here.

Experience has shown that it is difficult to control dimensions within close tolerances on machine parts involving internal forming operations. Amos had run into exactly that trouble with a certain hydraulic fitting made from rod that required a fairly close dimensional tolerance on the internal formed diameter. So, we decided to make a comparison test by machining the part from rod made by the conventional method and from rod produced by the S-C process. When rod made by the conventional method was machined, the parts could not be held within the specified tolerance range. The same machine, the same tooling and the same machine operator were used in this test, and when S-C process rod was substituted, the machine parts were well within the required tolerance range.

In addition, I just received a letter from a well-known equipment manufacturer who has been running tests on S-C rod. They reported that the incidence of tool trouble per 1000 forgings machined from S-C rod were approximately half that of forgings made from conventional rod. We think that is pretty good evidence that the rod made by our semi-continuous process is exceptionally uniform by all standards. Incidentally, our new billet casting department is quite a model of automation and has a number of interesting processes and features. Anytime you happen to be in our area we would be more than happy to show you through and explain the many points of this process that gives us what we firmly believe to be the best possible rod available today which of course is reflected in the quality of our forgings.

If you would like a folder that fully covers our semi-continuous process, just drop me a note and I'll see that one is sent along to you promptly. In the meantime, we'd like to have you investigate our super-cutting S-C rod because we think it will improve your product quality—and we've got the alloys to do most anything to meet the most exacting demands.

Thanks for your time.

MUELLER BRASS CO.

PORT HURON 20, MICHIGAN

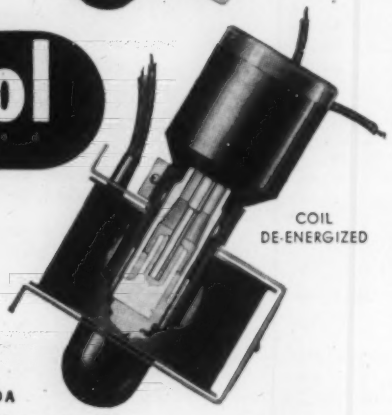
199

The **TIMER RELAY**
that handles all controlled timing problems . . .

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.

Durakool
STEEL MERCURY TIMERS

★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer



See telephone directory for local distributor, or write.
DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 WESTON RD., TORONTO 9, CANADA

Circle 508 on page 19

YOUR PUMPING JOBS
start fast
and finish fast
WITH VIKING PUMPS

When you install Vikings, there's no wasted time with slow, uncertain priming . . . you start delivering in seconds. Delivery is then smooth and constant. There's no spasmodic operation to cause damage to valves and meters. And to finish, you can strip a tank fast and completely with positive Viking Rotary Pumps. They are built to pump all liquids, thick to thin.

To start, send today for pump catalog 57Sh.

VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps
See our catalog in Sweets

Circle 509 on page 19

New Parts

(*Continued from Page* 171)

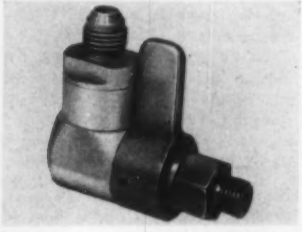
plifiers and motors. Particularly suitable for airborne applications, unit can be packaged for rugged environmental specifications with flexibility of configuration. Built-in preamplifier provides adjustable gain up to 5 v max at 1000 ohms output impedance. Voltage requirements are − 40, − 20 and + 20 v dc, and 115 v at carrier frequency. **Norden-Ketay Corp.**, Commerce Rd., Stamford, Conn.

Circle 724 on page 19

Quick Disconnect

operates at temperatures from −65 to 200 F

High - pressure quick disconnect safely and quickly disconnects a pressurized line with pressures up to 3000 psi. With handle in upright position (shown), integral floating ball-seat valve is fully open. To disconnect the line, handle is rotated 90 deg down. During



this movement the valve closes and pressure downstream from the valve seal is automatically bled out, allowing the line to be separated without danger. Unit operates at temperatures from −65 to 200 F. It is available in right-angle or straight-through configuration in aluminum, stainless steel, and Teflon seals. Line sizes include ¼, ⅜ and ½-in. Weight of ¼-in. model shown is 0.37-lb. **Hydromatics Inc.**, Cedar Grove, N. J.

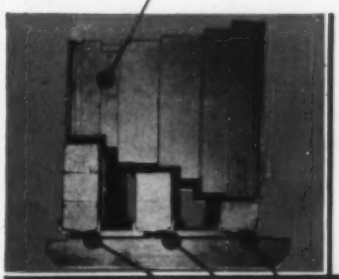
Circle 725 on page 19

Soldering Sheet

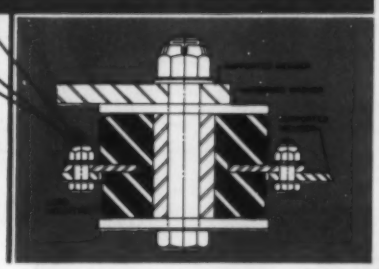
for soldering of heat-exchanger equipment

Zinc-clad aluminum alloy, available in commercial quantities, is fabricated with one or both sides clad, and in coil or flat sheet form. It is expected to help solve many joining problems associated with

radiation shielding windows protected in transit by LORD shipping mountings



Lord bonded rubber mountings provide a resilient but stable base for shipping massive glass casting.



Corning window is supported by eight Lord Heavy Duty Plate Form Mountings equipped with snubbing washers which limit and cushion excessive shock movement.

■ These 5000-pound glass castings used as shielding windows against nuclear radiation posed some unusual shipping problems.

Transporting these observation windows from the Harrodsburg, Ky. plant of Corning Glass Works to the installation sites exposed them to costly and irreparable damage. The weight, and irregular shape of the windows complicated the problem.

Lord research and engineering produced an economical solution by flexibly supporting the windows on eight Lord bonded rubber mountings. The mountings isolate vibration and reduce shock which might damage the glass. This move has paid off for Corning—no windows shipped on Lord mountings have been damaged!

If damaged shipments are costing you time, money and poor customer relations, take advantage of Lord's experience and facilities. Contact the Lord field engineer nearest you or the Home Office, Erie, Pa.

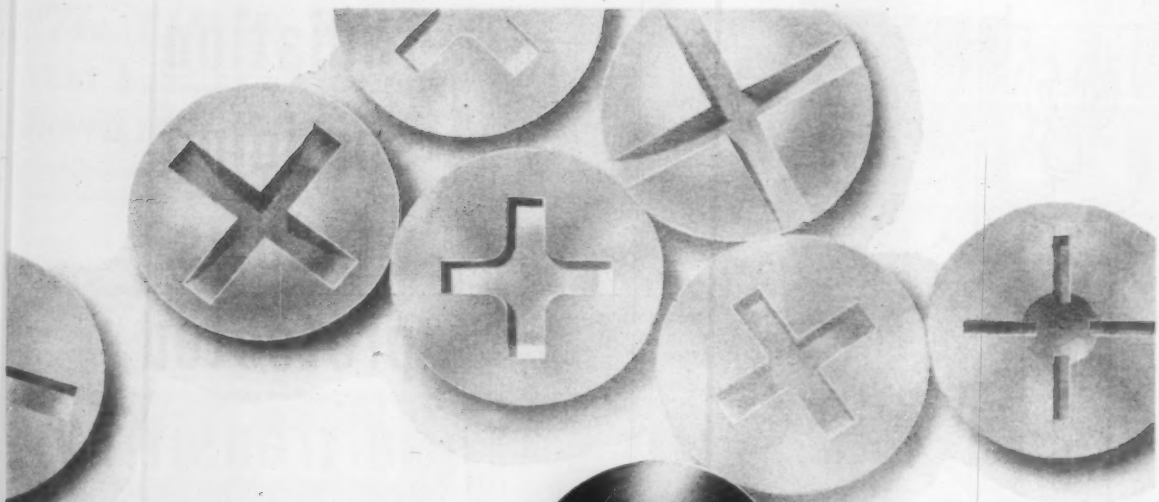
ATLANTA, GEORGIA - CEdar 7-1123
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - Michigan 2-6010
CLEVELAND, OHIO - SHadyside 9-3175
DALLAS, TEXAS - Riverside 1-3392
DAYTON, OHIO - Michigan 8871
DETROIT, MICH. - TRinity 4-2060
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - Circle 7-3326
PHILADELPHIA, PA. - LOcust 4-0147

"In Canada—Railway & Power Engineering Corporation Limited"

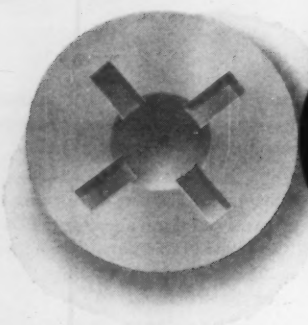
LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

LORD
BONDED RUBBER

designers and producers of bonded rubber products since 1924



hi-torque STANDS OUT IN APPEARANCE TOO

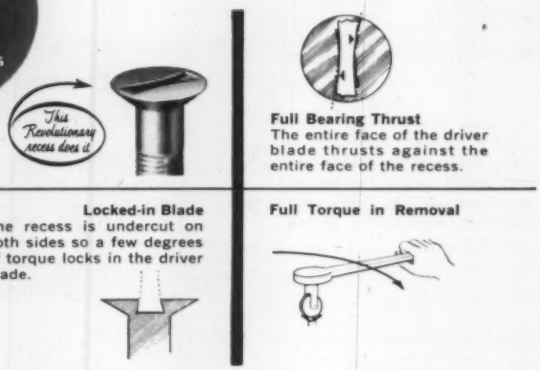


NO CONFUSION . . . THE ONLY RECESS THAT LOOKS LIKE HI-TORQUE IS HI-TORQUE

Unfortunately, all four wing recesses look basically alike. And one sure way to get involved in a time consuming, exasperating job of drilling out a screw or bolt is to grab the wrong type of four wing driver. But it can't happen with Hi-Torque. The only recess that looks like Hi-Torque *is* Hi-Torque! This distinctive, bow-tie recess instantly identifies it. And in case of emergency an acceptable Hi-Torque driver can be made in the field from a conventional straight slot screwdriver.

HI-TORQUE FASTENERS GIVE TWO TIMES TORQUE REQUIREMENTS

All Hi-Torque features are fully applicable in removal after field use and eliminates difficulties caused by temperature changes and structural loading. Write for brochure giving complete specifications and dimensions.


This Revolutionary recess does it
Full Bearing Thrust
The entire face of the driver blade thrusts against the entire face of the recess.
Locked-in Blade
The recess is undercut on both sides so a few degrees of torque locks in the driver blade.
Full Torque in Removal

VOI-SHAN

MANUFACTURING COMPANY

A division of PHEOLL MANUFACTURING COMPANY

8463 Higuera St., Culver City, California

Offices in principal cities of the United States and Canada

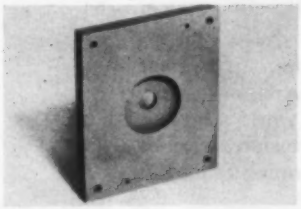
smooth and economical soldering of heat-exchanger equipment, particularly in the auto radiator field. Used with specially developed soldering techniques, zinc-clad aluminum will simplify normal maintenance and repair problems of soldered assemblies, in addition to reducing costs of production methods. **Aluminum Co. of America,** 1501 Alcoa Bldg., Pittsburgh 19, Pa.

Circle 726 on page 19

Servo Mounting Plates

fit most popular component parts

Complete line of servo-component mounting plates of 24ST aluminum provides either horizontal or vertical mounting of component. Plates are designed to fit standard



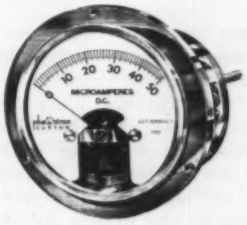
servo potentiometers, speed reducers, motors, synchros, autosyns, and generators. Finish is chromic-acid anodized. **PIC Design Corp.,** 477 Atlantic Ave., East Rockaway, N. Y.

Circle 727 on page 19

Magnet Meter Movement

has excellent sensitivities

Core-magnet meter movement has high linearity for 100 deg of scale arc. Sensitivities as low as 20 mu



amp are accomplished with a coil resistance of 3000 ohms. High spring torque provides ample stabi-

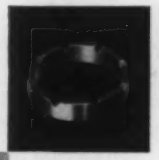
(*Continued on Page* 180)

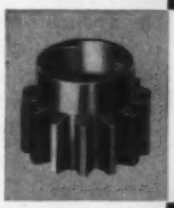
a new expanded field of

BEARING DESIGN and APPLICATION

The inauguration of Bunting's new facility for engineering and manufacturing bearings and parts of Sintered Powdered Metals opens a wide new area of opportunity to all mechanical industry.

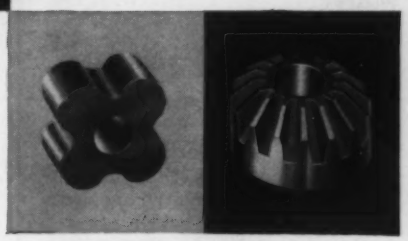
Sintered Powdered Metal Bearings and parts offer real economies in design. Bunting Engineering and manufacturing skill and traditional technical responsibility assure your most advantageous use of this material.





A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of both Cast Bronze and Sintered Powdered Metal Bearings and parts.

● *Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.*



Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

Circle 511 on page 19

MICRO SWITCH Precision

...FIRST IN PRECISION SWITCHING

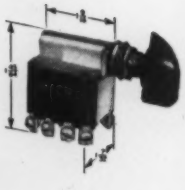
HOW MICRO SWITCH ENGINEERING SERVICE can keep a small switch from becoming a BIG PROBLEM in your design

MICRO SWITCH Engineering Service is a two-way street. Field engineers and factory engineers work together to make sure you get the right MICRO SWITCH precision switch for your application.

This teamwork between experienced switching specialists assures that the precision switches you incorporate in your equipment are the right switches for your application and will give reliable, dependable, day-in, day-out service.

You can take advantage of this teamwork by calling MICRO SWITCH today. Switching specialists—with close contact at the world's largest headquarters for precision switches—are available at branch offices in key cities.

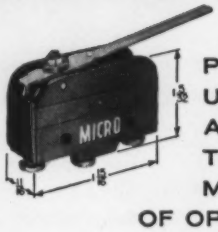
CONTROLS MANY CIRCUITS WITH ONE MANUAL MOTION



This three-position, rotary-type toggle switch offers all the advantages of a toggle switch mechanism with longer operating life and better detent "feel." Shown is a four-pole double-throw switch with 12 terminals. It is maintained in all three actuation positions, on-off-on. This switch can handle a high electrical load and has passed severe tests for impact, shock, acceleration and vibration.

(*Send for Data Sheet 112*)

PRECISE, UNERRING ACTUATION THROUGH MILLIONS OF OPERATIONS



Adjustable lever actuator permits close adjustment of switch operating point without removal from mounting. It provides unusually reliable service on such equipment as timers, computers or other multiple-mounted devices which require precise, unerring operation through millions of operations. Available with normally open, normally closed double-throw or split-contact circuitry.

(*Send for Data Sheet 100*)

FOR PRECISE PERFORMANCE UNDER MOST EXTREME CONDITIONS

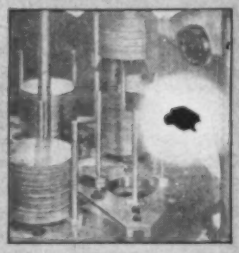
MICRO SWITCH "EN" switches are capable of reliable, long-life performance under extreme environmental conditions. They are completely sealed, cylindrical and can be mounted wherever a through hole can be provided. Variations of the "EN" are capable of actuation by almost any means. Available in choice of four different contact arrangements. Equal in performance to many switches twice the size.

Switches have uses unlimited

Switches put "THINK" into this press transfer feed

Here is a typical example of how a manufacturer improved his product. With MICRO SWITCH Precision Switches designed into the press, blanks are loaded and fed automatically, dangerous manual feeding is eliminated, mistakes are "erased" without interrupting production. This product improvement was due in no small measure to the help of MICRO SWITCH application engineers.

For more information for your design engineers, write for Catalog 83.

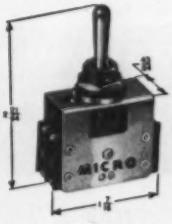


When a stack of blanks is nearly depleted, the descending elevator trips this switch which starts a motor and turns the six-station turret to the next full station for blanks.

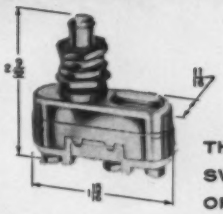
Plunger which picks up the blanks is controlled by switches shown. Upper switch stops the press if the blanks do not reach level of gripping fingers. Switch at left brings new stack of blanks into position. If stack doesn't come into position, the third switch stops press.

When two blanks stick together and feed into the press they trip this switch which actuates a solenoid and opens a trap door in the press bed. The blanks fall through, the press goes on uninterrupted.

SWITCH "REMEMBERS" CIRCUIT WHICH WAS LAST ACTUATED



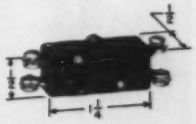
This is the first of a new series of "electrical memory" toggle switches. The switch indicates through a pilot light or buzzer which circuit was last actuated. The assembly uses one pole of its four-pole circuitry to indicate which circuit was last operated. Use of this switch simplifies basic circuit designs of radar units, computers, aircraft control panels and other similar devices. Seal prevents entrance of liquids and dust. Basic switches are Underwriters' Listed at 5 amperes 125, 250 volts a-c, d-c rating at 28 volts-3 amperes at sea level, 2.5 amperes at 50,000 feet (inductive); 4 amperes at sea level and 50,000 feet (resistive); maximum inrush, 15 amperes.



THIS SWITCH OPERATES RELIABLY AT TEMPERATURES FROM −50° TO +1000° F

Use of laboratory-tested, heat-resistant materials makes this switch an extremely dependable component for use in applications where high temperatures are present. It will operate satisfactorily in a temperature range of −50° to 1000°F. Contact arrangements are single-pole double-throw. Switch is available in panel-mount design (shown) or with pin- or roller-plunger actuators.

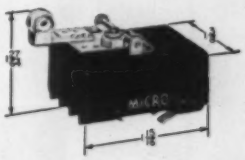
(*Send for Catalog 77*)



A TWO-CIRCUIT SWITCH WITH ACCURATE REPEATABILITY

This switch uses a snap-action spring to provide quick make and break of both contacts in each double-break circuit. It is Underwriters' Listed for 10 amperes 125 or 250 volts a-c; ½ H.P. 125 volts a-c; 10 amperes 30 volts d-c.

(*Send for Catalog 62*)



TWO SWITCHES OPERATED BY A SINGLE LEVER ACTUATOR

This is an assembly of two single-pole double-throw switches. It provides for switching of two isolated circuits at the same time. The basic units are listed by Underwriters' Laboratories at 15 amperes 125, 250 or 460 volts a-c; ½ ampere 125 volts d-c; and ¼ ampere 250 volts d-c.

(*Send for Data Sheet 100*)

MICRO SWITCH, a Division of Honeywell, pioneered the manufacture and development of precision snap-action switches.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Let us take over your inventory problem!

Immediate Delivery

ANY BORE SIZE • ANY MOUNT • ANY STROKE

CARTER CYLINDERS

Sounds too good to be true, but here's real help for engineers and designers who need fast action on cylinders. Carter's exclusive key type locking design and simplicity of parts *makes it possible to ship cylinder orders in 24 hours or less!* Now you can have rugged, dependable, compact quality cylinders when you want them. We produce around the clock. Your order is in process *minutes after we get it.*

Service on spare parts is good too! Experienced engineers and parts stocks are located in 40 different locations in the U. S., Canada and Mexico.

PHONE SERVICE 24 HOURS A DAY

Orders taken day or night. If you need fast service call your Carter representative or the plant. LANSING, ILLINOIS, GRanite 4-3305 or CHICAGO, BAyport 1-7186. Teletype LNSG, ILL 1119X

Complete Catalog File!

Complete bound file with ordering details for: Air Cylinders; 750 Lb. Hydraulic; 1500 Lb. Hydraulic; Clamp Cylinders; Air Valves; Built-in Valve Type Cylinders. Complete with parts data, specifications and prices. Send today!

CARTER CONTROLS INCORPORATED

2914 Bernice Road • Lansing, Illinois (Chicago Suburb)

AIR CYLINDERS • HYDRAULIC CYLINDERS • AIR VALVES
ROTARY ACTUATORS • SPECIAL CONTROLS

(*Continued from Page* 177)

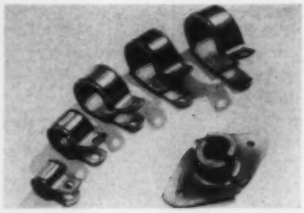
lity. Mechanical design includes sintered rings and pole faces, precision die-cast brackets, and shock-mounted jewel assemblies. Movement is available in 2½ in. round clear-plastic case. **Phaostron Instrument and Electronic Co.,** 151 Pasadena Ave., South Panadent, Calif.

Circle 728 on page 19

Aircraft Clamp

withstands temperatures from — 300 to 500 F

Joclamp, suitable for temperature extremes encountered during jet-engine operation at high altitudes, withstands temperatures from — 300 to 500 F. Clamp lining is made by molding to shape an asbestos wire-reinforced strip impregnated with Teflon. Material combines excellent high-tempera-



ture characteristics of asbestos with electrical, chemical and mechanical properties of Teflon. Clamp is impervious to hydraulic fluids, lubricating oils, corrosive fuels and solvents. Lining has coefficient of friction of 0.04, and excellent resiliency. Clamp absorbs impact shocks, vibration and dimensional changes due to expansion and contraction. **Joclin Mfg. Co.,** North Haven, Conn.

Circle 729 on page 19

Safety Switches

in wide range of types meet new NEMA standards

Three types of safety switches meet new NEMA standards. Type LD switch for light duty includes a full range from 30 to 200 amp in both general purpose and raintight enclosures. Type ND for normal duty and commercial work extends from 30 through 1200 amp in both 250 and 600 v, ac and dc,

Circle 513 on page 19

Seeburg designers choose P-K screws

to match the fastener to the job!

Joseph Kamys, engineer, J. P. Seeburg Corporation, Chicago, manufacturers of coin operated phonographs says, "Seeburg standards demand attention to every detail—quality workmanship and materials throughout. With Parker-Kalon screws, we can match the fastener to the specific application—be sure of dependable results."

Attachment of metal base molding and kickplate to a Seeburg cabinet, in a metal-to-wood application. "Rather than use ordinary wood screws, we power-drive P-K Self-tapping Type-A," says Mr. Kamys. "Holding power is far better, there's less chance of wood splitting, and fewer rejects at inspection."

Here, metal rims of two high-frequency speakers are fastened to a formed, one-piece, plastic housing. "In this metal-to-plastic application we have not only the problem of possible plastic breakage, but the fastener used must be highly resistant to vibration. We find P-K thread-forming Type-Z screws highly satisfactory."

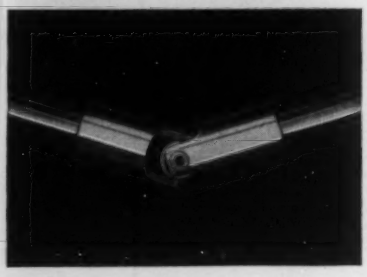
If you are designing a new product or new model, it will pay you to talk with a Parker-Kalon Field Engineer. He can help in the selection of proper fasteners, can often suggest ways to speed production—cut costs. You can contact him through your local Parker-Kalon Industrial Supply Distributor.

***PARKER-KALON DIVISION,** General American Transportation Corporation, Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws.*

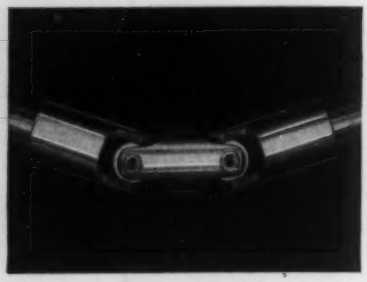
Sold Everywhere Through Leading Industrial Distributors. Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois, Los Angeles, Calif.

PARKER-KALON®
fasteners

How Curtis helped a design engineer "BEAT THE HEAT"



This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



Curtis engineers recommended a *double* Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

CURTIS UNIVERSAL JOINTS

because our catalog torque and load ratings are substantiated by constant tests under production conditions.

14 SIZES ALWAYS IN STOCK —
3/8" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.

5 Birnie Avenue, Springfield, Mass.

As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 515 on page 19

New Parts

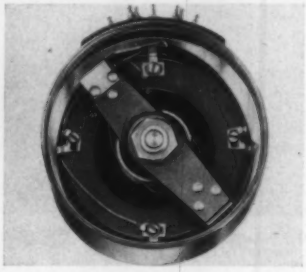
in general-purpose or raintight enclosures. This type has a quick-make, quick-break operating mechanism independent of the handle, and silver-plated, current-carrying parts. Type HD for heavy-duty industrial use is available in gasketed industrial type as well as water and dust-tight and explosion-resisting types. **Square D Co.**, 6060 Rivard St., Detroit 11, Mich.

Circle 730 on page 19

Potentiometer

has function accuracy of 1 per cent

Model C-300 high-precision sine-cosine function potentiometer is a 3-in. enclosed unit from which two separate voltage outputs can be obtained. Independent brush contacts are mounted on a common shaft 90 deg apart to produce ac-



curate sine and cosine voltages. Function accuracies of 1 per cent are standard, and function angle is 360 deg. Either sleeve or ball bearings can be supplied in one-piece aluminum housings. Mounting designs include servo, three-hole with central pilot, or threaded bushing. Multiple ganged units are available with sections in simultaneous or other conformity. All insulating materials and metals have maximum resistance to humidity and salt spray. **DeJur-Amsco Corp.**, Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 731 on page 19

Stuck for an answer?

Roll this one around

You can move a pen across paper—or a liner across the ocean—on Universal balls.

Yes, Universal balls have done both—and more. They're precisioneered to 10 millionths of an inch—made in just about any kind of metal you want.

You can get your ideas rolling on a ball—in any direction you want to go.

Just send us a card and we'll roll some of our ideas your way!

UNIVERSAL QUALITY CONTROL—
FOR ALL AROUND PERFECTION

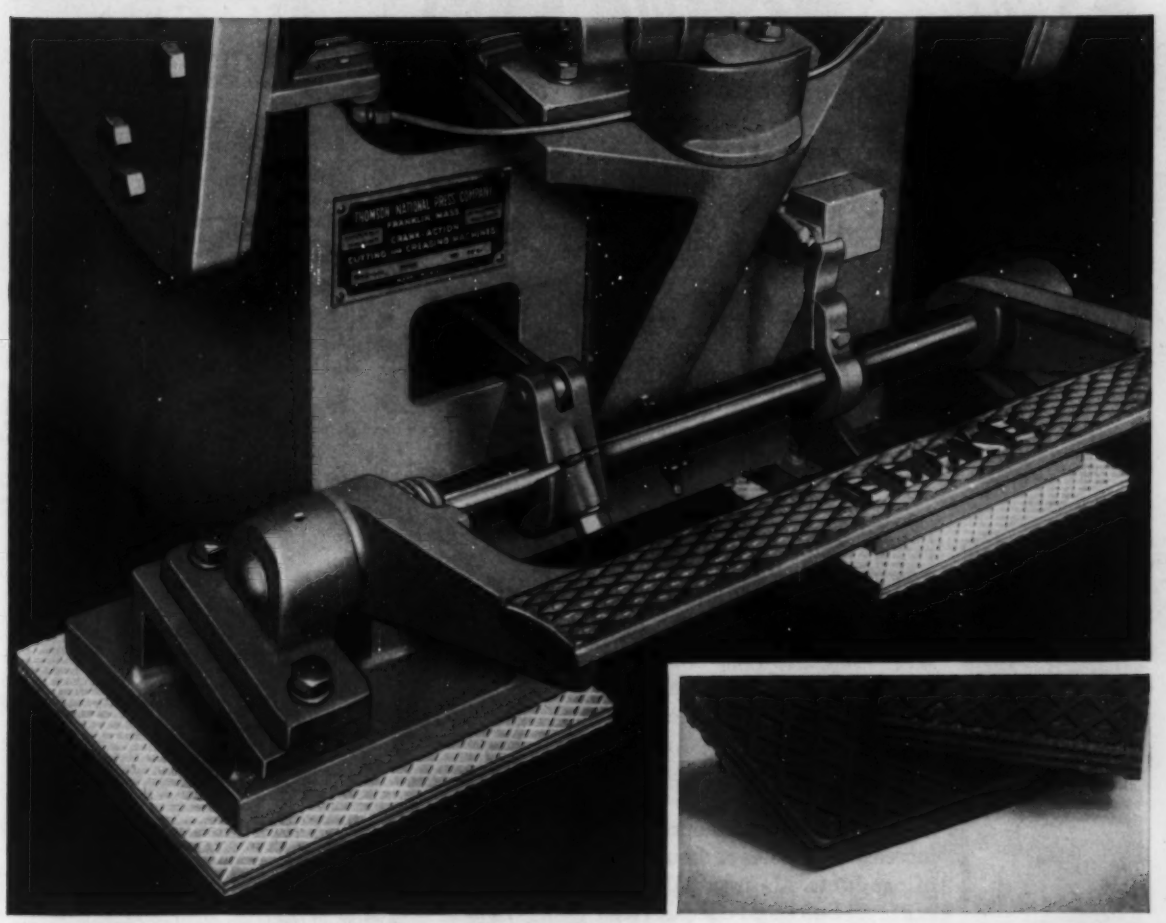
Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

Circle 516 on page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



"Air-Loc" Machine pads are made by Clark-Cutler-McDermott Company, Franklin, Mass.

Machine pads made with Geon "snap back" after repeated 1000 psi loads

THIS new machine mounting pad to reduce machinery noise and vibration is quickly installed without bolting or cementing.

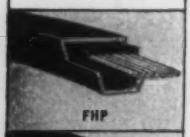
The pads are made of Geon polyvinyl resin, sisal, and granulated cork, fused into an integrated pad. Geon resin binds the materials, makes the pad resistant to water, oil, grease, most acids and alkalis. The pad is strong, yet flexible. Even after repeated loadings to 1000 pounds per square inch, the pad recovers 99% of original thickness.

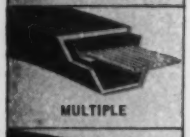
Geon polyvinyl resins, compounds, latices, and polyblends are highly versatile materials that can make *your* products better too. Use Geon for extrusion-molding—or a superior coating. For information write Dept. DO-2, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

Mor-Grip v-belts





Maurey *engineers* v-drives for every situation; the "stop and go" spurts of refrigeration drives; the pulsating, high torque loads of rock crushing; the smooth, steady-pull of textile drives... for short centers, and wide range of speed ratios. Maurey V-drive equipment has proved its value since 1917, improving the performance, and increasing the sales of thousands of products. Maurey delivers pulleys, belts and accessories *quickly* from complete stocks. Whether you are designing a new v-drive or improving an old one, contact Maurey. Call your local Maurey Distributor, or write direct.

Request These Catalogs

CATALOG V-55

CATALOG MVD-56

CATALOG F-10

MAUREY-MATIC CATALOG

Pulleys, Sheaves V-Drive Accessories

maurey manufacturing corp.

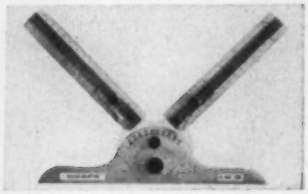
2903-27 SO. WABASH AVE., CHICAGO 16, ILL.

ENGINEERING DEPARTMENT EQUIPMENT

Scale Protractor

has vernier for accurate settings fom 0 to 90 deg

Drafting instrument of acrylic plastic has two beveled scales attached to a swivel quadrant that



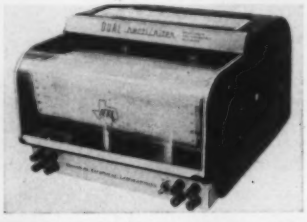
rotates on base to provide desired scale angle. Vernier permits accurate settings and clamp screw locks at desired angle. Scales are 6 or 12 in. long. **Alvin & Co.,** Windsor, Conn.

Circle 732 on page 19

Rectilinear Recorder

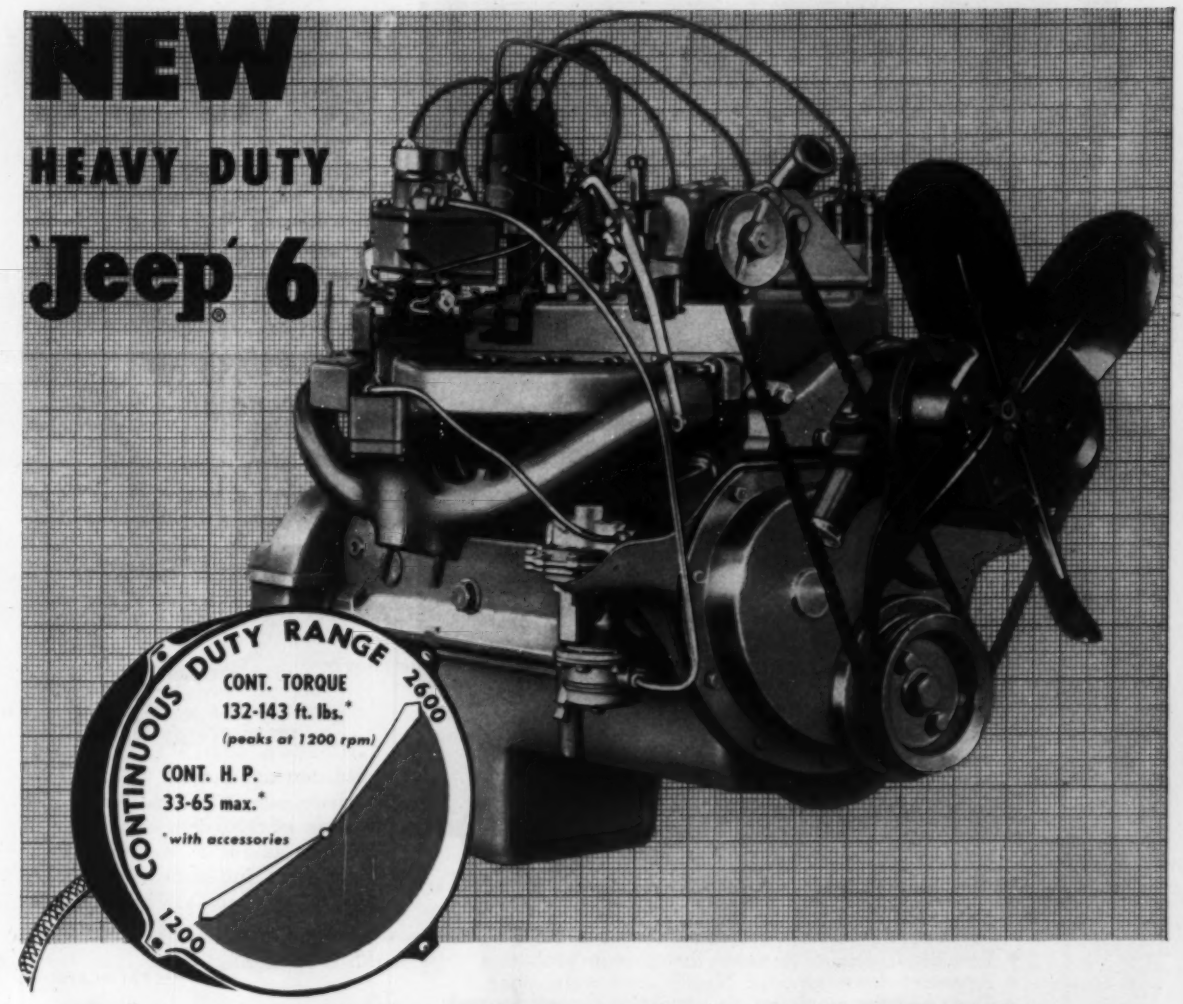
has high deflection sensitivity

Dual Rectiriter galvanometric strip chart recorder monitors two functions simultaneously in true wave forms. Using a single chart drive, it records two variables on a two-



channel rectilinear chart with a common time base. Unit has high deflection sensitivity, is adaptable to a variety of circuits, and has no warm-up time or drift problems. Design features include writing desk area for manual notations on the chart, front-located zero adjust, front-mounted controls and signal terminals, and finger tip

Circle 518 on page 19



HIGH TORQUE where you need it!

When your equipment meets heavy loads at low rpm . . . that's when it needs the extra lugging power provided by this new, high torque engine.

And check this for sheer ruggedness: the Heavy Duty 'Jeep'-6 was put through repeated 100 hour tests at 4,000 rpm under full load. Each test was equivalent to over 50,000 miles of normal vehicle travel. Results: *no breakdowns . . . no parts failures.*

The "Keypoint Engineered" features such as valve rotators, hard faced valves and others are standard equipment . . . for economical, dependable power at minimum first cost.

Write today for full details and prices of the new Heavy Duty 'Jeep'-6 and the famous 'Jeep'-4's.

These Keypoint Engineered Features Assure Long Engine Life, Low Upkeep

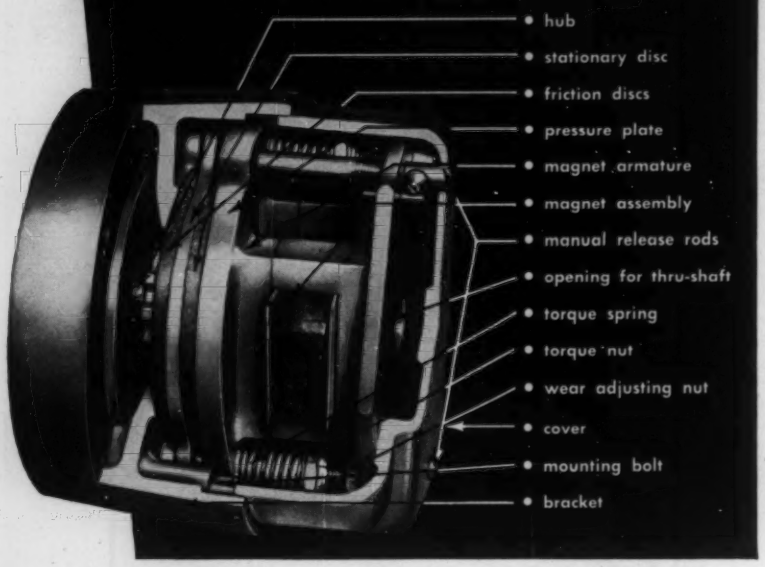
- *Positive valve rotators and Stellite or Eatonite valves.*
- *Four ring aluminum alloy pistons with hard chrome compression ring and hard chrome steel oil ring.*
- *New heavy duty bearings.*
- *100% counterweighted, forged crankshaft.*

Jeep

WILLYS MOTORS, INC. *Industrial Engine Department* **TOLEDO, OHIO**

COMPARISON PROVES

DINGS *direct-acting*
MAGNETIC DISC BRAKES
are your best buy!



COMPARE these outstanding advantages

- Direct-acting for positive, instantaneous stops
- Thru-Shaft design to solve installation problems
- Accommodate standard NEMA shaft extensions
- Designed for mounting on all old and new re-rated NEMA type "C" motor flanges
- Wide torque range—1½ to 175 lbs. ft.—easy torque adjustment
- Fail-safe design in event of power failure
- Simple design and rugged, compact construction

COMPARE for operating and maintenance economy

- No mechanical linkages or levers to maintain
- No solenoids required
- No need for auxiliary fuses, rectifiers, rheostats, auxiliary relays or extra wiring

NEW DINGS EXPLOSION-PROOF MAGNETIC DISC BRAKES
UL approved for hazardous locations

Now Dings combines all the advantages of direct-acting magnetic disc brakes with explosion-proof features tested and approved by Underwriters Laboratories . . . the "707" Series for Class I, Group D hazardous locations, and the "709" Series for Class I, Group C and D and Class II, Groups E, F, G.

Always specify Dings Brakes from your regular motor supplier, or ask about Dings complete engineering service for your brake problems.

DB157½

d|b

DINGS BRAKES, INC.
A Subsidiary of Dings Magnetic Separator Co.
4714 W. ELECTRIC AVE. • MILWAUKEE 46, WISCONSIN

Engineering Equipment

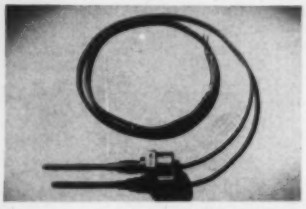
ten-speed gear shift chart drive. Meter movement is available in 1, 5, 10 or 25 ma input for 4½-in. deflection, and has a dc accuracy of ± 1 per cent of full scale. **Texas Instruments Inc.**, Industrial Instrumentation Div., P. O. Box 6027, Houston, Tex.

Circle 733 on page 19

Temperature Pick-Up

is ultra-sensitive unit with high vibration resistance

Type 1300 stainless-steel bulb temperature pick-up is precision high-speed resistance thermom-



eter having output up to 5 v without amplification. Resistance change of 100 ohm can occur in as little as 100 F. Accuracy is ± 1 per cent full scale range under 25*g* to 2000 cps vibration. **Trans-Sonics Inc.**, Box 328, Lexington 73, Mass.

Circle 734 on page 19

Recording Oscillograph

has three methods for recording data

Dynograph is a high-speed, direct-writing oscillograph for recording dynamic and static variables. Traces are made by ink, heat or electricity, with either curvilinear or rectilinear coordinates. Single or multichannel assemblies are obtainable in console, rack mounting or portable cases. **Offner Electronics Inc.**, 5320 N. Kedzie Ave., Chicago 25, Ill.

Circle 735 on page 19

Electronic Counter

7-lb unit has ± 1 per cent accuracy

Portable electronic counter combines plug-in electronic decade, 5-digit mechanical register, input amplifier and pulse shaper. Counting

Circle 520 on page 19

compare LINK-BELT with any other geared flexible coupling

Here are the features that build acceptance for the compact LINK-BELT design

New LINK-BELT design saves SPACE and COST

1 LARGE GEAR DIAMETER with respect to external dimensions reduces gear tooth pressure.

2 ACCURATE GEAR TEETH with controlled clearance to permit misalignment with minimum backlash.

3 RIGID ASSEMBLY of two-piece housing with special hardened steel cap screws and lock washers.

4 POSITIVE RETENTION OF LUBRICANT—and exclusion of dust and water—with special compound O-ring seals.

5 GREATER BORE CAPACITY lets you use a smaller coupling where shaft size dictates selection.

6 SIMPLE ASSEMBLY requires only an Allen wrench.

Ask your nearest Link-Belt office for Folder 2375. Or mail the handy coupon today.

LINK-BELT COMPANY
Prudential Plaza,
Chicago 1, Ill.

Please send me a copy of Folder 2375, covering Geared Flexible Couplings.

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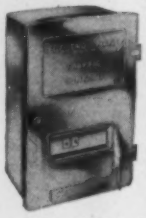
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,782-R

TCB = ?
TCB = HB

Problem: What method can best be employed to cast our large Traffic Control Box . . . and who can satisfy our exacting requirements?

Solution: Aluminum Permanent Mold Casting . . . by Hampden Brass & Aluminum Co.

This was the solution Eastern Industries, Inc. found to their problem of housing the delicate "brain" of their radar traffic control system.



Pictured here is the end result . . . a non-corrosive, uniquely weather-proof, snug-fitting box, completely safe from tampering.

The permanent mold process was chosen by Hampden because it produces a fine, non-porous casting . . . the surface requiring no preparatory finishing before painting. The box was used as cast, thereby eliminating expensive profile machining for producing the rabbet fit of the box and doors. The high production rate and lower over-all cost of the permanent mold process prove additional advantages. Aluminum was selected for its lightweight and durable qualities.

Remember . . . whether your casting problems are big, tiny, intricate, or special . . . Hampden is ready to effectively solve them with premium quality castings of aluminum or other non-ferrous metals . . . utilizing the sand, permanent mold or die casting method. Our more than 50 years' know-how is your assurance of the best casting techniques to help reduce costs and improve performance.

Why not contact Hampden Brass & Aluminum Co. on your next casting problem . . . and avail yourself of our engineering counsel?

Send for brochure, "Behind the Scenes" . . . complete digest of Hampden's experience, equipment and facilities.

HB

HAMPDEN BRASS AND ALUMINUM CO.

Established 1903

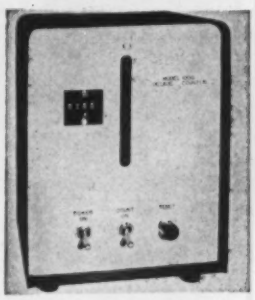
262 Liberty St.•Springfield, Mass.

Producers of Sand, Permanent Mold, Die & Fiberglas Castings

Circle 522 on page 19

Engineering Equipment

rate is to 12,000 counts per minute; unit responds to 2.5 v pulses. Count capacity is 999,999 with ac-



curacy of ± 1 per cent. **Performance Measurements Co.,** 15301 W. McNichols Rd., Detroit 35, Mich.

Circle 736 on page 19

Force Gages

offer choice of four compression heads

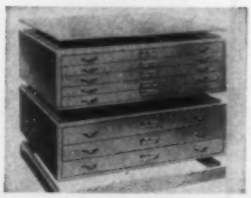
Mechanical force gages hold maximum reading after load is removed. Four units have maximum load ca-

pacities of 50, 100, 150, and 200 lb. Control button selects desired operation (to hold maximum reading or to follow load fluctuations). **Hunter Spring Co.,** Apparatus Div., Lansdale, Pa.

Circle 737 on page 19

Blueprint File

interlocks with other file units



Inter-Member blueprint file interlocks with existing units, meeting government requirements. File

NEEDED...

MECHANICAL ENGINEERS

MECHANICAL DESIGNERS

---to make ELECTRONICS *systems work!*

Don't think you have to get away from the mechanical field or make a big readjustment in order to build a brighter future *faster* in the expanding Electronics Industry! No sir, you can use your particular training, skill and ability to the fullest; because most electronics systems are mechanical in operation!

•

At Bendix Radio you'll find us acutely aware of your professional status, we have important, challenging work for *you* . . . and the way up the ladder of success is *faster.* That's because Bendix Radio is a respected leader in the development and production of the world's finest military and commercial electronics systems.

•

You will design mechanical and electro-mechanical electronic devices. Mechanical problems to be solved involve packaging, chassis, gearing, bearing surfaces, cooling and heat dissipation, shock and vibration, stress analysis and model shop techniques. You will supervise mechanical and electrical draftsmen.

•

You will benefit most at Bendix Radio, because of our *rapid expansion.* You will receive top pay, periodic merit reviews and *all* company benefits, including company assistance in graduate education. Our new, modern plant is located in a beautiful suburban area.

•

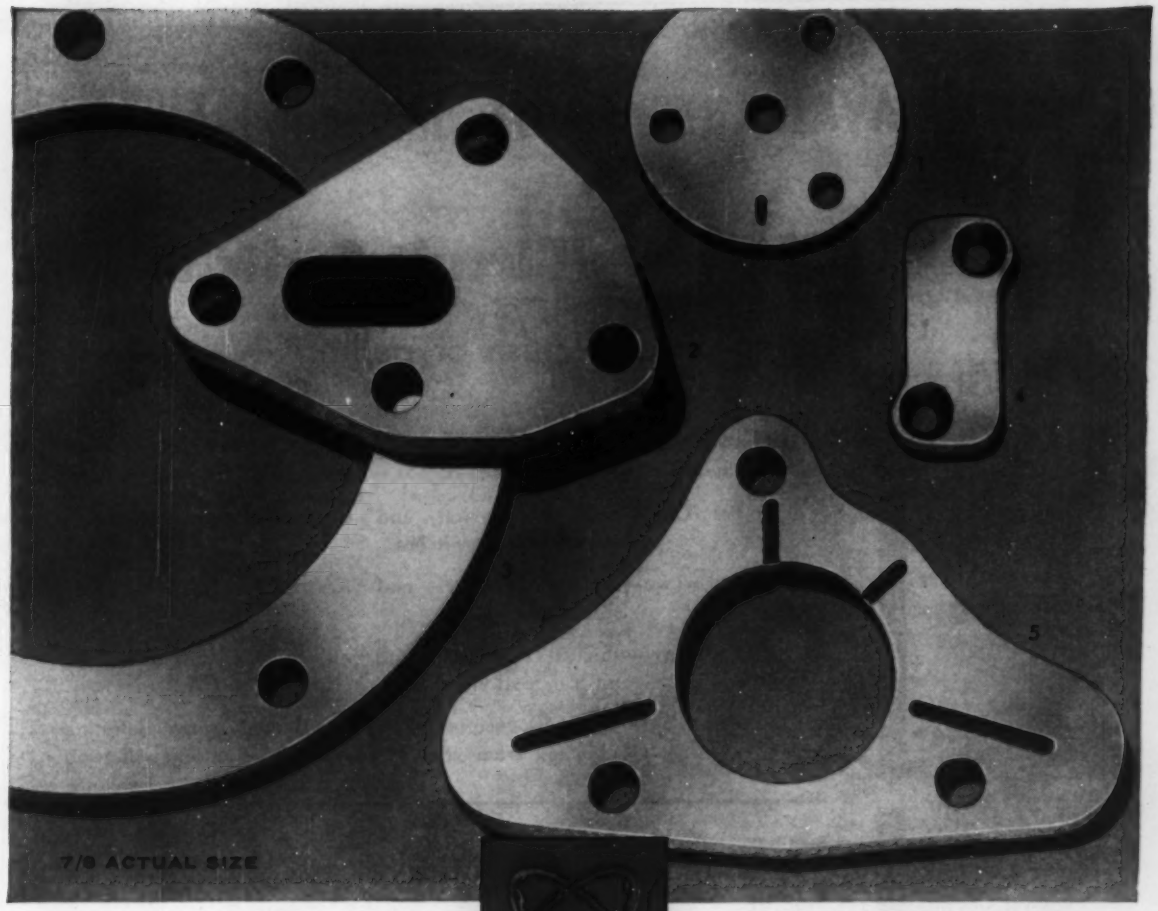
For immediate response, just drop us a postal card. Briefly state your education and experience. Address:
Employment Supervisor, Dept. D

BR Bendix

DIVISION OF BENDIX AVIATION CORP.
BALTIMORE 4, MARYLAND

Radio

Circle 523 on page 19



From the producer of piston rings **used in 1 out of every 3 new cars . . .**

Precision castings at "captive cost"

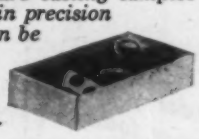
Muskegon's Sparta Foundry now offers the finest in small precision castings—at surprisingly low cost! Consider these advantages:

1) Complete service from design conception to finished product.
2) Ready-to-install parts—with surface finishes and flatness to your specifications; with width tolerances to within plus or minus .001"—completely deburred, drilled, reamed or tapped.
3) Castings of high carbon cast iron, high strength alloy cast iron, cast bronze and sintered powdered metal parts—plus Muskegon developed Spartaloy metals to meet unusual heat, wear and corrosion needs.

(1) Compressor thrust plate. (2) Valve cover plate. (3) Crankshaft retaining ring. (4) Automatic transmission governor cover plate. (5) Camshaft thrust plate.

WRITE FOR YOUR FREE SAMPLE KIT

This assortment of miniature casting samples shows what is being done in precision castings . . . what metals can be used . . . how they can be formed and machined for you. Write today! Sparta Foundry Co., Sparta, Mich.



Since 1921... The engine builders' source!

Circle 524 on page 19

REPRINTS AVAILABLE FROM MACHINE DESIGN

Multiple-Circuit Switches

lever – rotary – push or pull

A design manual on the factors to be considered in the selection and application of multiple-circuit switches.

Part One—discusses physical and electrical characteristics of lever-operated switches

Part Two—discusses physical and electrical characteristics of rotary switches

Part Three—discusses physical and electrical characteristics of push or pull switches

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Circle 738 on page 19

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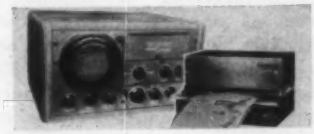


tions for testing or adjustment of rotating and oscillating devices. Unit gives visual picture of waveform content over wide range, making it easy to check frequency and amplitude of any component or to compare and analyze data. **Panoramic Radio Products Inc.**, 10 S. Second Ave., Mount Vernon, N. Y.

Circle 739 on page 19

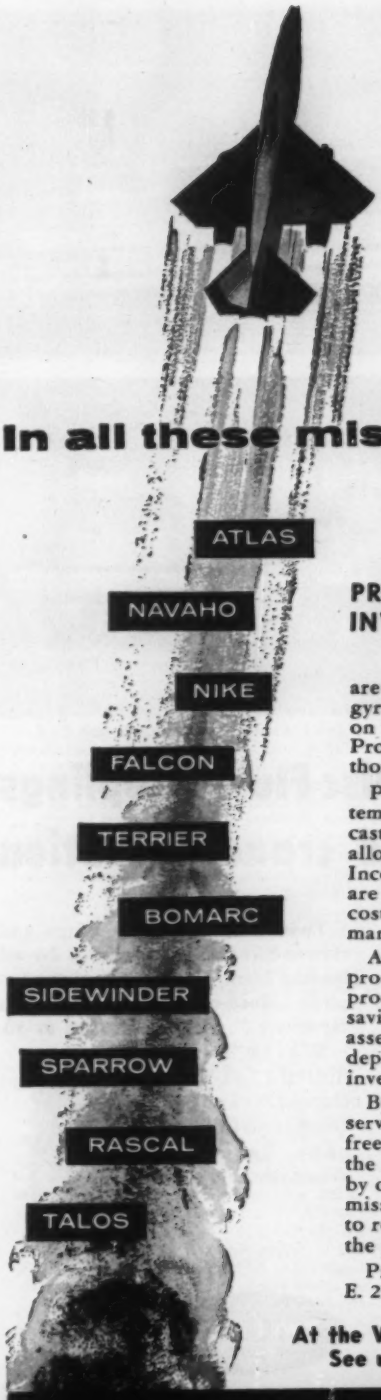
Oscillator

covers 5 to 5000 cps range in continuous band

DY-2200 sweep oscillator covers 5 to 5000 cps frequency range in one continuous band, eliminating range changing, switching transients, and

dial discontinuities. Instrument requires no zero setting. Unit is available in standard rack-panel mounting or in portable cabinet. **Cynac Inc.**, 395 Page Mill Rd., Palo Alto, Calif.

Circle 740 on page 19



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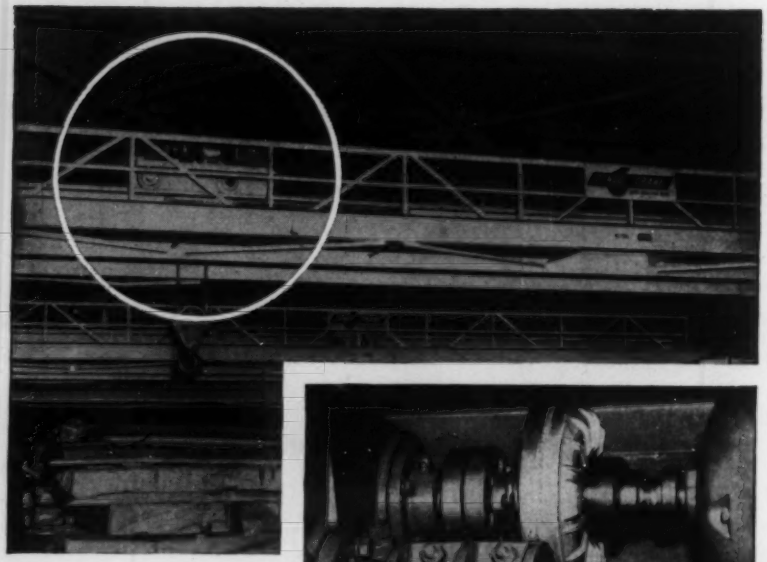

Above. Two of three Conco Engineering Works 10-ton, 55' span, 3-motor, floor-operated, overhead cranes in a mid-western steel warehouse. Right. Close-up of the Twin Disc Fluid Coupling installation showing simplicity and compactness of drive arrangement.

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THE ENGINEER'S Library

Recent Books

Physical Mathematics. *By Chester H. Page, consultant to the director, National Bureau of Standards;* 329 *pages,* 6 *by* 9 *in., clothbound; published by D. Van Nostrand Co. Inc.,* 120 *Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, $7.50 *postpaid.*

This book explains the mathematical methods of physics in terms of physical interpretation, extension by physical intuition, and theoretical demonstration. The need to view a given set of physical phenomena from various viewpoints is emphasized. Since many solutions are possible, it is essential to avoid computational details until the engineer or physicist knows what type of solution is most informative. It is often necessary to develop various mathematical devices in discussing one general problem. The book traces the logical development of some of the classical mathematical techniques. By helping the engineer to correlate his mathematical knowledge, this book improves his feeling for the subject and increases its usefulness for the individual who applies mathematical tools to physical problems.

Theory of Land Locomotion. *By M. G. Bekker, technical director, Land Locomotion Research Laboratory, Detroit Arsenal;* 520 *pages,* 6 *by* 9 *in., clothbound; published by University of Michigan Press, Ann Arbor, Mich.; available from* MACHINE DESIGN, $12.50 *postpaid.*

This book gives information now available on relations between a motor vehicle and the physical environment in which it operates. It lays the foundation for a new type of applied mechanics by systematizing the accumulated experience of men in the field to present an integrated theory of land locomotion. Placing particular emphasis on off-the-road vehicles, the book discusses in de-

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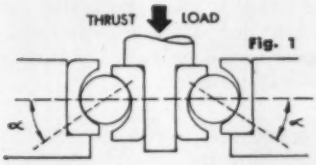
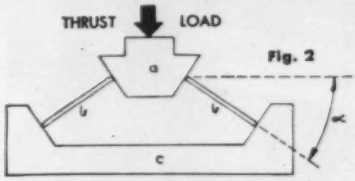
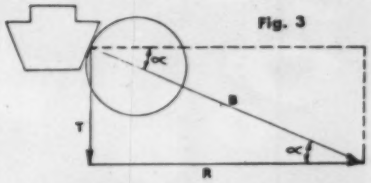
Subject: **CONTACT ANGLE**







THRUST LOAD CONSIDERATIONS

Contact angle is the angle between a plane perpendicular to the bearing axis and a line connecting the two points on a given ball where the ball makes contact with the raceways when the bearing is subjected to a pure thrust load. In *Fig. 1*, the contact angle is represented by angle *a*. The significance of the contact angle is revealed by an examination of the forces present in a thrust loaded bearing.

In *Fig. 2*, a simplified version of *Fig. 1*, the shaft and inner ring combination are represented by the plug *a*, the "working diameters" of the balls are represented by the rodlike members at *b*, and the outer ring is represented by the tapered cup *c*.

The contact angle is *a*. This diagram represents a three-dimensional structure with as many equally spaced rods, *b*, as there are balls in the bearing.

The primary concern in design is the amount of compressive force to which rod *b* is subject, which is the force with which a given ball is pressed against the raceways. This force can be calculated by constructing a parallelogram of forces as shown in *Fig. 3*.

The sides T and R, are vector quantities, and diagonal B is the vector sum of T and R. Furthermore, the vector sum of the thrust components on all the balls equals the total thrust load on the bearing. The vector sum of the radial components on all the balls is zero. Vector B, the force actually felt by the raceways and balls, compared to vector T, the thrust component, varies significantly with changes in the size of the contact angle and is directly proportional to the thrust load component and inversely proportional to the sine of the contact angle.

Example I:

A bearing is carrying a pure thrust load of 21 pounds. Assuming seven balls in the bearing, each ball will have an axial load component of three pounds, since a thrust load is shared equally by all the balls. While the axial component on each ball is only three pounds, the actual compressive force, or squeeze, felt by the ball and raceways is considerably greater than this value.

With a contact angle of five degrees:

$$B = \frac{T}{\sin a} = \frac{3 \text{ pounds}}{\sin 5^\circ} = 34.5 \text{ pounds}$$

Thus we see that with a five-degree contact angle the actual load felt by each individual ball is actually considerably greater than the total 21 pound thrust load on the bearing.

Example II:

Using the thrust conditions in Example I, the contact angle is increased to 20 degrees, by selecting a bearing with a larger value of radial play.

$$B = \frac{3 \text{ pounds}}{\sin 20^\circ} = 8.78 \text{ pounds}$$

A 15 degree increase in contact angle produced a 74.5% reduction in ball-to-raceway contact stress. This relationship should be noted by anyone who writes bearing specifications. The operational qualities of the bearing, such as low running and starting torque and bearing life, are a function of the ball-to-raceway contact stress. Thus the contact angle is highly significant.

It is not necessary for a bearing user to calculate or specify the contact angle desired. It is only necessary to remember that low values of contact angle are associated with low radial play, and high values of contact angle are associated with high radial play.

While the advantages of large contact angle have been examined above in some detail, there is one important factor which, in high speed applications, places a restriction on the magnitude of contact angle for optimum bearing performance. This is the matter of gyratory forces on the balls. Each ball in a bearing may be visualized as a little planet rotating on an orbit represented by the pitch circle of the bearing, while at the same time rotating about an axis of its own. It is this latter mode of rotation which concerns us at the moment. Every rotating body exhibits gyroscopic characteristics which vary in magnitude with the speed of rotation. Most important of these characteristics is the reaction of the rotating body to changes in the direction of its axis. Now the axis of rotation of a ball in a bearing is represented by a line which passed through the center of the ball and which is perpendicular to the line connecting the points of contact with the raceway. This means that the angle between the axis of ball rotation and the axis of the bearing is equal to the contact angle *(see Fig. 4)*.

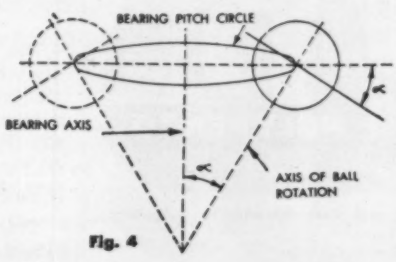


Fig. 4

As the ball travels around its pitch diameter orbit, the axis of ball rotation is forced to change constantly. Specifically, the gyratory moment acting on a ball is proportional to, among other factors, the sine of the contact angle. Thus as the rotational speed is increased, a point will be reached where the gyratory forces acting on the balls will produce slippage between the balls and the raceways. This induces increased operating temperature as well as premature bearing failure.

Thus in high speed applications, optimum bearing performance is a compromise between high contact angle for minimum ball-to-raceway stress, and low contact angle for minimum slippage between balls and raceways.

RADIAL LOAD CONSIDERATIONS

With a pure radial load, the load at any instant is not shared equally by all the balls as in the case of thrust loading, but is supported by three or four balls at most. The higher the radial play, the greater is the tendency for the load to be concentrated on one or two balls; while the lower the radial play, the more the load is apt to be distributed on three or four balls. This more even distribution of load in radially loaded bearings with low radial play is reflected in reduced torque and extended bearing life.

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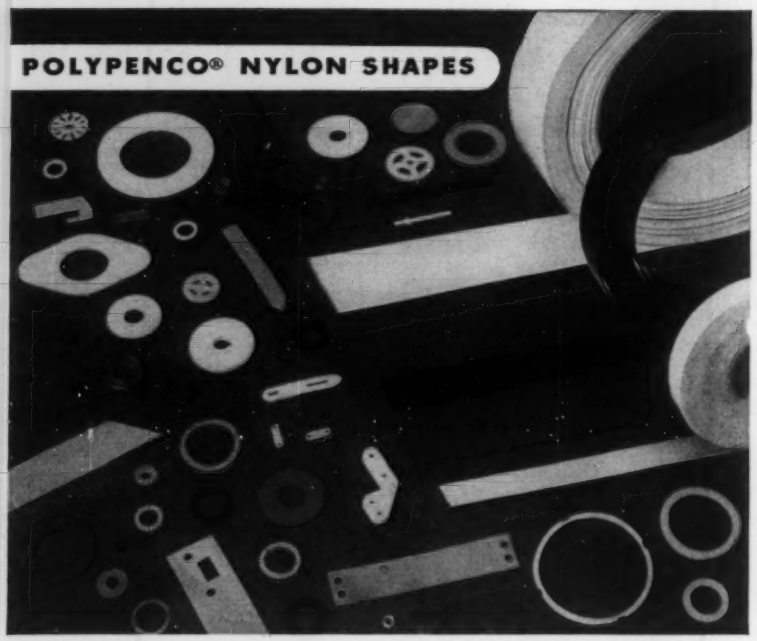

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Electronics in Industry. *By George M. Chute, professor of electrical engineering, University of Detroit;* 431 *pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 W. 42nd St., New York* 36, *N. Y.; available from* MACHINE DESIGN, $7.50 *postpaid.*

This book presents a broad introduction to the use of industrial electronic circuits and equipment. The book is suitable for use as a reference work for the practical engineer or as a text by the student. The material is presented in terms of equipment already in use and thus presents proven examples of efficient design practice.

Numerical Analysis, Volume VI, Proceedings of the Sixth Symposium in Applied Mathematics. 303 *pages, 7 by 10 in., clothbound; prepared by the American Mathematical Society; published by McGraw-Hill Book Co. Inc., 330 W. 42nd St., New York* 36, *N. Y.; available from* MACHINE DESIGN, $9.75 *postpaid.*

Of interest to applied mathematicians, computer-programming technicians, computer designers, physicists and engineers, this volume contains all but two of the papers presented at the meeting held at Santa Monica City College, co-sponsored by the American Mathematical Society and the National Bureau of Standards. The subject of the symposium was numerical analysis. The book indicates the increase in attention to this subject by mathematicians in recent years.

The Condensed Chemical Dictionary. *By Arthur and Elizabeth Rose;* 1220 *pages, 6 by 9 in., clothbound; published by Reinhold Publishing Co., 430 Park Avenue, New York* 22, *N. Y.; available from* MACHINE DESIGN, $12.50 *postpaid.*

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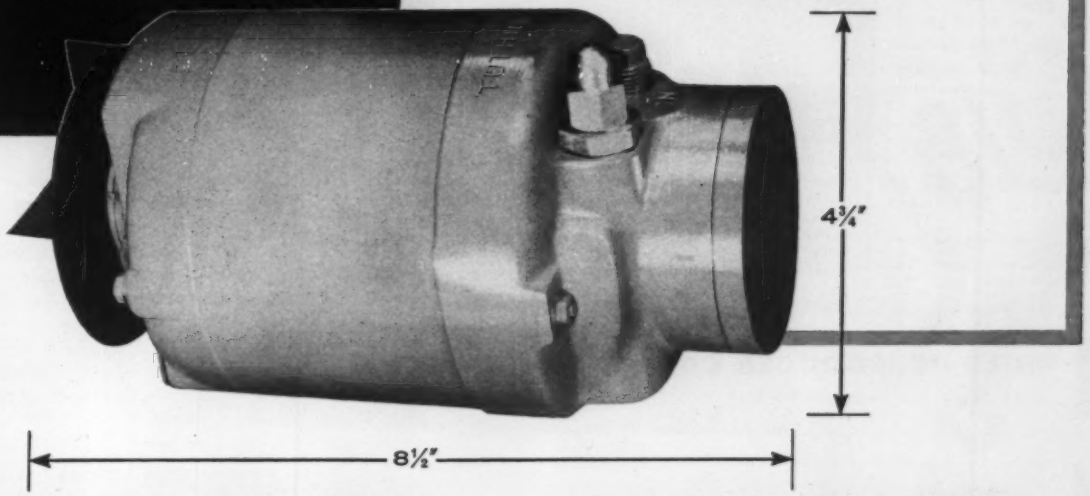

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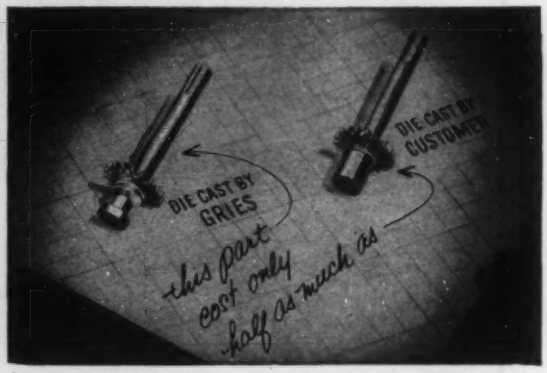

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Circle 530 on page 19

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Perspective. *By Jay Doblin; director, Institute of Design, Illinois Institute of Technology; 68 pages, 9⅛ by 12 in., clothbound; published by Whitney Publications Inc., 18 East 50th St., New York 22 N. Y.; available from* MACHINE DESIGN, $5.00 *postpaid.*

This book presents a system developed to solve the kind of drawing problems encountered by designers. It eliminates the complex perspective layout that is normally employed in the traditional way of working from plans and elevations. The system offers a simple method of visualizing any three-dimensional object accurately and quickly.

Viscous Flow Theory; Laminar Flow. *By Shih-I Pai, research professor, Institute for Fluid Dynamics and Applied Mathematics, University of Maryland; 384 pages, 6 by 9 in., clothbound; published by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, $7.75 *postpaid.*

Extensive mathematical theory available is applicable to ideal fluids which are assumed to be inviscid and incompressible but fails to explain many phenomena of viscous flow. This investigation of real fluids concentrates on those areas in which the effects of viscosity and compressibility are most significant. This book presents methods of solving problems in these fields.

Association Publications

Resistance Welding Manual, Volume I. *Edited by E. J. del Vecchio; 350 pages, 6 by 9 in., clothbound; published by and available from Resistance Welded Manufacturers' Association, 1900 Arch St., Philadelphia 3, Pa.; $3.00 per copy.*

This book, the third edition, is

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Government Publications

A High-Speed Reader for Perforated Tape, PB 121057. *By Richard Bianco, Aberdeen Proving Ground; 17 pages, 8 by 10½ in., paperbound, sidestapled; prepared by Ballistic Research Laboratories; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; 50c per copy.*

A perforated-tape reader is described which is simple in concept, troublefree, easy to operate, and very fast (1000 characters per second). Reading head consists of six photoelectric cells to read standard five-channel tape. Sprocket hole is used for timing purposes. Schematic diagrams and typical observed wave shapes are included.

NACA Technical Series. *Each publication is 8 by 10½ in., paperbound, sidestapled; copies available from National Advisory Committee for Aeronautics, 1924 F St., N. W., Washington 25, D. C.*

The following Technical Notes are available:

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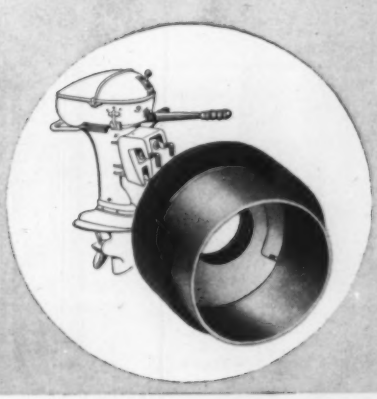
As part of the cooling system for an outboard motor, a neoprene impeller had to rotate at 4,000 r.p.m. in a sleeve. The abrasive action on the sleeve was devastating. If the sleeve were out-of-round or had any tolerance deviation it accumulated sand or silt, which destroyed the impeller. The answer to the problem was Damascus Welded Stainless Steel Tube.

Welded stainless steel tube insures:

- Close tolerance
- Abrasion resistance

If the design problem can be solved by tube, remember Damascus Welded Stainless Steel Tube is "your best buy."



DAMASCUS TUBE COMPANY

STAINLESS STEEL TUBING AND PIPE

GREENVILLE, PENNSYLVANIA

Circle 532 on page 19

LUBRICATION A PROBLEM? . . .

why not try *Purebon

* CARBON-GRAPHITE ESPECIALLY DESIGNED FOR MECHANICAL APPLICATIONS

Where lubrication is a problem on bearings, seals, blades and similar sliding or rotating parts, Purebon is often the ideal solution.

PROPERTIES OF PUREBON

1. Moldable to size.
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3. Chemically inert.
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5. Light weight.
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For complete information about PUREBON write for new Bulletin No. 55, or see Sweet's Product Design File

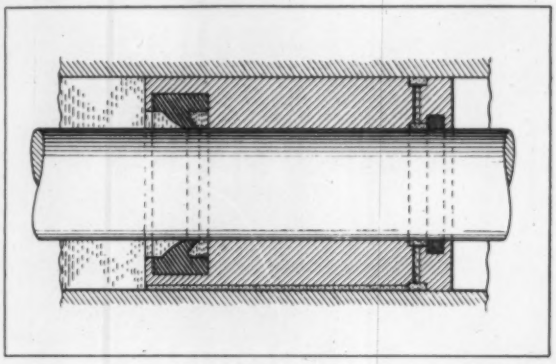
PURE CARBON CO., INC.
442 HALL AVENUE ST. MARYS, PENNSYLVANIA

NOTEWORTHY

Patents

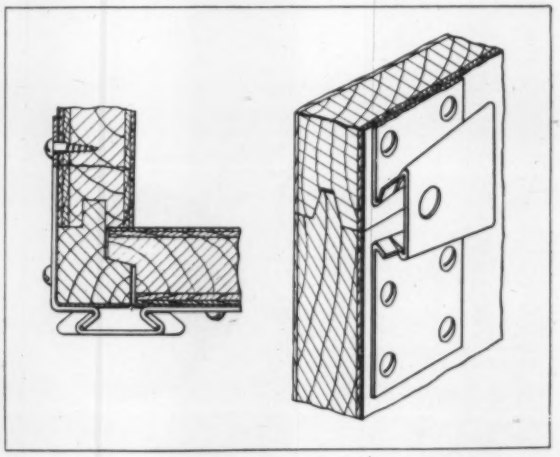
Reciprocating-Shaft Bearing

Positive lubrication of bearing and shaft surfaces is provided by a reciprocating - shaft bearing, incorporating a one-way wiper seal and lubricant recirculating passages. When the shaft enters the bearing, wiper seal (left) permits free passage of the shaft oil film into the journal. The shaft is wiped clean when its movement is in the opposite direction. Escape of lubricant beyond the bearing journal is blocked by a second seal (right). Lubricant collected in the bearing by the action of the wiper seal is recirculated to the reservoir through an annular collector-ring and port arrangement. *Patent* 2,776,173 *assigned to Borg-Warner Corp. by Marion F. Rudy.*



Panel Clamps

Wedge-like tightening action of sheet-metal clamps, for use in construction of elevator cabs or similar enclosures, provides a tight joint between panels. Particularly adapted for use with interlocking panel-edge treatments, the clamps comprise three parts:



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Circle 534 on page 19

A wide variety of uses for

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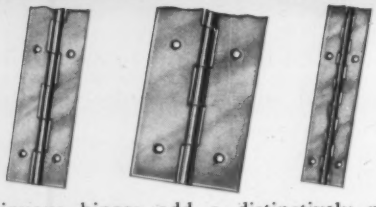


Continuous hinges add a distinctively modern and neater appearance to cabinets, machinery, combination doors and displays.

Stanley can provide these hinges in various metals, all useful widths and lengths, with or without screw holes — all furnished to your particular requirements.

Write for folder G-72R with specifications and applications. Stanley Hardware, Division of The Stanley Works, 693 Lake Street, New Britain, Conn.

STANLEY

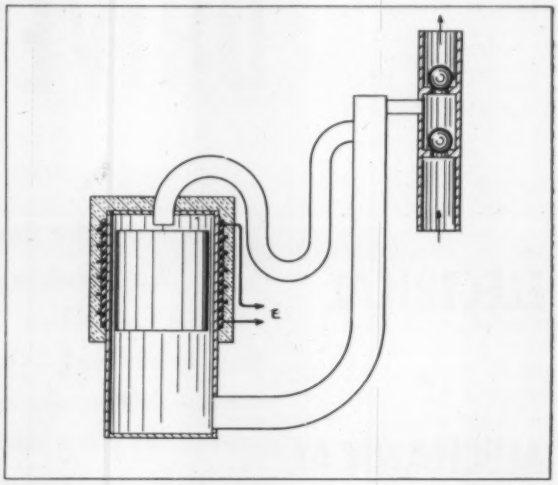
Circle 535 on page 19

Noteworthy Patents

a pair of brackets, which are secured to adjacent panel edges; a wedge-shaped clip, which mates with the tapered bent-up edges of the brackets. When driven over the brackets, the clip draws the panel edges firmly together, forming a rigid, attractive joint. *Patent* 2,774,121 *assigned to Otis Elevator Co. by Henry Ludwig Graevenitz.*

Heat-Actuated Pump

Incorporating only a float as a moving part, a noiseless, heat-actuated thermopump transfers fluids such as water or fuels from a supply source to a



delivery point by automatic reversal of relative rates of vaporization and condensation. Check-valve system (upper right) alternately fills pump with liquid, allows vapor pressure of evaporated fluid to force fluid to delivery point. Float in main pump chamber (shown with insulated heating coils at upper end) reduces area of contact between liquid and vapor, thereby minimizing undesirable convective heat transfer between hot and cold parts of the thermopump. *Patent* 2,744,470 *assigned to Jet-Heat Inc. by Robert E. Coleman.*

Engagement of mating clutch jaw teeth in a stamped-metal quick-disconnect coupling ensures precise positioning of clutch elements. Nonsymmetrical location of multiple studs and apertures permits engagement of the clutch in only one angular phase position. Clutch elements are locked together after engagement by a flexible spring which is rotated into position to engage the slotted stud ends. Typical uses include quick coupling of adjustable control elements, such as dial and condenser assemblies. *Patent* 2,738,210 *assigned to United States of America by Alf H. Hjembo.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

For EMERGENCIES
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Available in popular types and sizes of threads for high or low pressure installation

Emergencies will happen with even the best hose, but you can greatly minimize the costly down time resulting from hose failure in the hydraulic system. Put idle men and equipment back to work quickly. No special tools—no hose stripping necessary. Anchor Clamp-Type Couplings are easily applied to bulk hose you carry on the job, and may be used over and over again. They insure a firm hold under conditions of impulses and vibrations. Their compact design is an advantage in applications of limited space and a convenience when used with Anchor adapter unions and related fittings. Always have a supply of Anchor Clamp-Type, Reusable Couplings on hand in assorted sizes.

Anchor Clamp-Type, Reusable Couplings are also furnished assembled with hose to satisfy your requirements for heavy duty original-equipment service.

Ask for complete details—
send your specifications for recommendations

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Circle 536 on page 19

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Look to Beckett for advanced design! A complete line—150 models—of air and hydraulic directional control valves ... *precision-built, economically priced!* Send for catalog.

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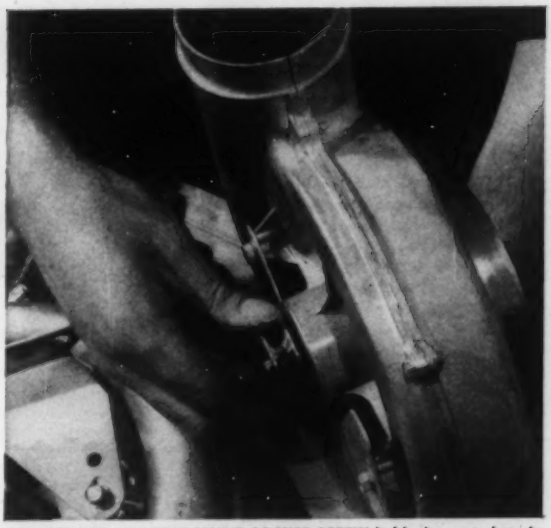


ONE BRISTOL MULTIPLE-SPLINE SOCKET SCREW holds sheave to hot air unit impeller shaft in Lovell laundry dryer.

Runs lab tests...buys Bristol socket screws

That, in brief, is the report we get on Bristol socket screws from Stephen E. Riley, Purchasing Agent, for the Lovell Manufacturing Company, Erie, Pa., world's largest manufacturer of clothes drying appliances for domestic use.

"Our laboratory . . . made a series of comparison tests," Mr. Riley said, "employing various types of screws to fasten the drum shaft to the sheave. It was discovered that only Bristol Multiple-Spline socket screws, properly applied, would not loosen, but would bind indefinitely.

"Our engineers determined to use the Bristol screw exclusively . . ."

And that's not all. "The usage of two Bristol Multiple-Spline socket screws . . . not only increased our drum shaft protection, but resulted in a 10% saving . . ." The reason, Mr. Riley explained, was that the necessity for flatting the shaft of the 35-pound drying drum was eliminated, thus saving machining costs.

This is typical of the experience of Bristol socket screw users—with Bristol-originated Multiple-Spline or industry standard hex socket. They like the Multiple-Spline's ability to take extra wrenching torque enabling them to resist shock and vibration. And they like the precision workmanship of both hex and Multiple-Spline.

Find out about Bristol socket screws today. Sold through leading industrial distributors. A.6.29

FASTENING SHEAVE TO SHAFT of 35-pound drying drum with Bristol Multiple-Spline screw.

Precision socket screw manufacturers since 1913

*Made in sizes as small as No. 0 in Alloy Steel and Stainless Steel. Cap Screws up to 1½".

THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

Circle 538 on page 19

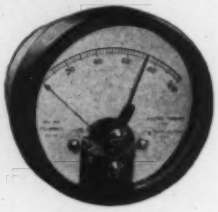
NEW METER-RELAYS

FROM 0-5 MICROAMPERES - UP

Ruggedized-Sealed, Black Bakelite, or Clear Plastic Cases

D'Arsonval indicating meters with built-in locking contacts for sensitive and accurate control or alarm

TRIP POINT ADJUSTABLE to any point of scale arc. Sensitive to changes as little as 1%. One contact carried on moving pointer. The other on an adjustable pointer. When two pointers meet, contacts close and lock. Holding coil is wound directly over moving coil, locking action is electro-magnetic. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully.



Model 255-C, Single Contact, High Limit, 0-10 Volts DC $42.50

Model 461-C, Double Contact 10-0-10 Microamps DC $83.25

Ranges from 0-5 microamperes or 0-5 millivolts up, full scale. Temperature ranges from 0-300°F. (10 ohms external) have bimetal cold junction compensation.

Standard Contact Rating 5 to 25 milliamperes DC. Can be built up to 100 milliamperes DC.

Ruggedized-Sealed metal cases are 2½", 3½" and 4½" round, shock-mounted, gasket-sealed.

Black Bakelite case, 4½" rectangular.

Clear Plastic cases are 2½", 3¾", and 4½" rectangular. Maximum visibility and lower cost.

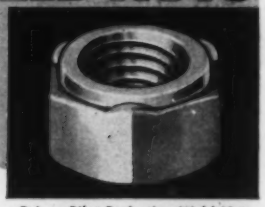
Panel meters and indicating pyrometers are also available in ruggedized-sealed, black bakelite or clear plastic cases. New 40-page catalog lists prices and specifications for meter-relays, meters, pyrometers and automatic controls using meter-relays. Write for Catalog 4-A, **Assembly Products Inc., Chesterland 51, Ohio. HAmilton 3-4436 (Cleveland, O.)** (West Coast: Box XX, Palm Springs 51, Cal, Phone: DHS 4-3133 or 4-2453.)

Booth 232 Atomic Expo. Booth 3916 IRE Show

Circle 539 on page 19

These 2 WELD NUTS

for blind assemblies



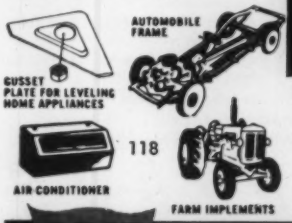
will give you

- **Easier Positioning**
- **Quicker Fastening**
- **Extra Threaded Depth at**
- **Less Cost**

Available with or without Gripco locking feature. Three weld projections on bottom of nut provide a firm non-rocking electrical connection during welding. Write for samples and full details today.

Gripco Pilot-Projection Weld Nut, circular pilot designed, provides quick, easy positioning of nut in bolt hole for instant resistant welding. No jigs, no fumbling, no waste of time. Weld spatter can not foul threads. Two heights for different metal gauges.

Gripco Countersunk Weld Nut eliminates time-wasting retapping of nuts after welding. Exclusive countersunk nut bottom eliminates fouling of threads by weld spatter. No time wasting false starts, no cleaning of damaged threads, nut ready to receive bolt immediately.



GRIP NUT COMPANY

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Circle 540 on page 19

HEAVY DUTY D. C. SOLENOIDS

MODEL SS

VOLTAGES . . . . (D.C. Only) 6V. 12V. 24V. 32V.

CURRENT DRAW . . (Pulling) 50A. 30A. 17A. 7.5A.

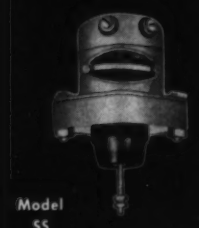
CURRENT DRAW . (Holding) 1.7A. .95A. .28A. .25A.

DUTY . . . . . Continuous

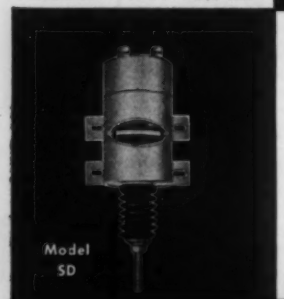
CYCLES . . Not to exceed 6 per minute

PULL . . Approximately 10 lbs. over ½" stroke

WEIGHT . . . . . 2¼ lbs.



Model SS



Model SD

MODEL SD

VOLTAGES . . . . (D.C. Only) 12V. 24V. 32V. 115V.

CURRENT DRAW . . (Pulling) 31A. 26A. 16A. 3.6A.

CURRENT DRAW . (Holding) .60A. .31A. .19A. .07A.

DUTY . . . . . Continuous

CYCLES . . Not to exceed 6 per minute

PULL . . Approximately 10 lbs. over 1½" stroke

WEIGHT . . . . . 4 pounds

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The Newest of Mayline Products

To the ever expanding line of Mayline drafting room furniture has now been added a steel 4-Post table. Base is of heavy gauge steel, wood feet have inset no-mar levelers, all metal drawers run on ball bearing rollers, top is solid basswood with steel edges.

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Circle 542 on page 19

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WIRE FORMS
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In Industry, in homes, farms and shops, you'll find daily, living proof that D-&-B's KNOW-HOW pays out in EXTRA performance. Rely on expert engineers for parts that meet your exact needs and save you MONEY! Get Wire Forms, Springs and Stampings that are easily assembled . . . that withstand stress . . . and perform under the most trying conditions!
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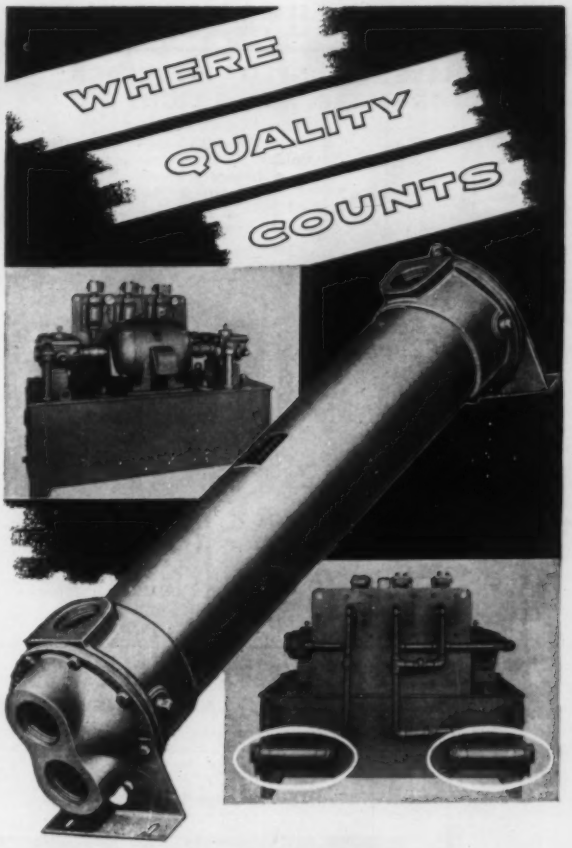
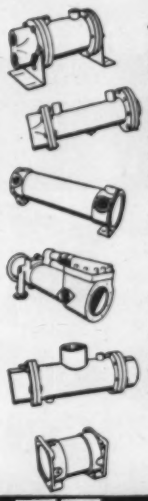
Circle 543 on page 19



Special Hydraulic Power Units rely on **Young** *Heat Exchangers*



Stock models or specially engineered Young Heat Exchangers are used for heating or cooling of process and hydraulic fluids, heat reclaiming, compressor cooling, and scores of other applications. Rating high on elimination of expansion strains, smoothness of flow, prevention of leakage, economy of initial cost and operation expense, Young Heat Exchangers can be depended upon *where quality counts.*

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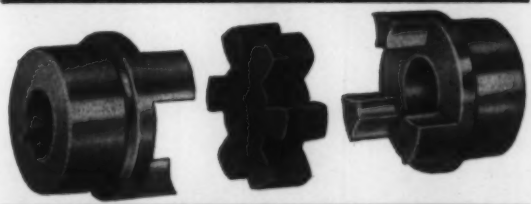

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The exclusive CONCAVE jaw surfaces of the Gerbing Flexible coupling actually holds the Buna-N rubber insert or spider within the jaws and prevents the rubber from extruding under load. Effectively absorbs shock, vibration, and misalignment. Requires no lubrication. Available for shafts ½" to 2⅛" and H.P. ranges from fractional thru 30. Deliveries from dealer and factory stocks. Increase your coupling service life. Write for complete information.

Concave jaws hold spider in position at all times . . . no extruding

Hub, bore, and outside diameter concentricity assure vibration-free operation.

Dept. M-3

Gerbing
MANUFACTURING CORP.
Northbrook, Ill. (Suburb of Chicago)

Circle 544 on page 19

Circle 545 on page 19

Automatic **INSURANCE POLICY**

HAYS "SHUR-FLO" INTERLOCK FOR WATER, AIR OR LIGHT OIL

- Prevents equipment or systems failure.
- Senses a specified fluid flow rate to an electrical circuit.
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- Pressures to 150 psi.
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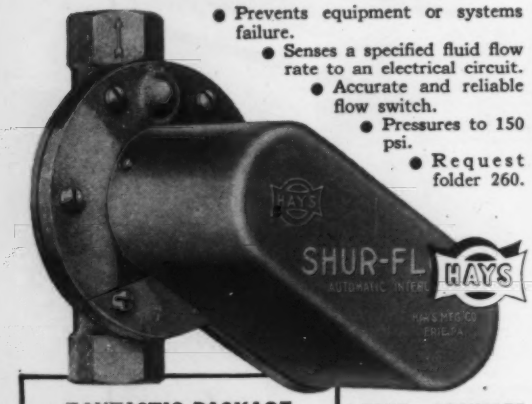

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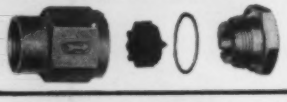

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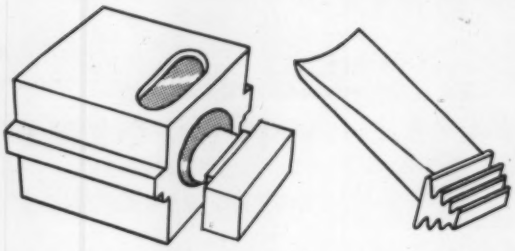
Circle 546 on page 19

Hold irregular workpieces rigidly by nesting them in CERRO ALLOYS



The unique combination of low melting temperature and non-shrinking qualities in CERRO ALLOYS make them an excellent nesting matrix in jigs, chucks and fixtures for irregular shaped pieces. The illustration shows how a jet engine "pinetree" turbine bucket can be held snugly in a special fixture for grinding. After locating the bucket properly in the large cylindrical hole, the latter is filled with molten Cerro Alloy. After grinding the bucket, it is removed from the fixture by melting out the matrix in hot water. In such applications the low melting temperature of the Alloy eliminates all danger of annealing or burning the workpiece.

See you at Booth #848
Western Metal Exposition

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300 Park Avenue, Room 1508 New York 22, N. Y.

Circle 547 on page 19

Send your specifications for prompt quotation

Hundreds of standard

JONES TERMINAL PANELS

Complete Equipment FOR **SPECIALS**

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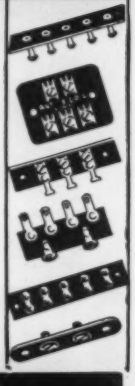
See the Jones Display at The I.R.E. Show—Booth 2535



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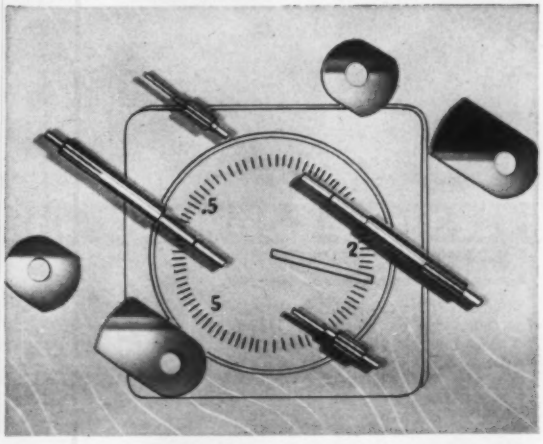

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CLUSTER GEARS • RACKS • INTERNALS • ODD SHAPES

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1031 PARMELE ST. ROCKFORD, ILLINOIS

Circle 549 on page 19

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AJUSTRITE®
DRAFTING CHAIR

Three Sizes
20" x 28"
24" x 32"
28" x 36"

- 2" Upholstered Seat
- No Soiled Hands Adjusting Seat
- 2-Way Adjustable Back Rest
- Full Swivel Seat

Model
RUC 2230

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The AJUSTRITE CHAIR enables the user to quickly and easily adjust the height of the seat up or down to suit his individual requirements—without soiling his hands.

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Also available with round metal or wood seat, formed plywood or solid hardwood saddled seat. Gray or green finish optional.

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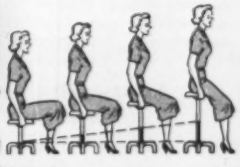
FREE TRIAL

Use AJUSTRITE Chair or Stool for 30 days without obligation. Prove to yourself the many advantages AJUSTRITE offers. Guaranteed against failure due to defective material or workmanship for a period of 10 years.

SPLIT SECOND
ADJUSTMENT
. . . to any Height Desired



Circle 550 on page 19

FREE SAMPLES and APPLICATIONS of INDUSTRIAL FELT*

*made to S.A.E. and Federal Govt. Specifications

See why
CONTINENTAL FELT
fills hundreds
of jobs daily

SEE HOW FELT FITS IN WITH YOUR PRODUCTS

Ask for booklet M-3

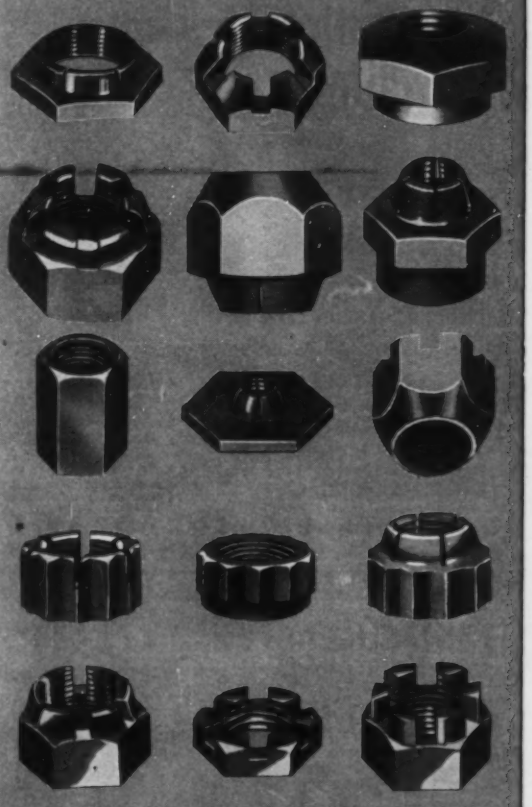
CONTINENTAL **FELT** COMPANY, INC. 1909
22 26 WEST 15th STREET NEW YORK 11, N. Y.

Circle 551 on page 19

SPECIAL NUTS

to specs. 7/16" - 4-1/4" cross flats

special machines + large stock of material × years of experience = speedy deliveries high quality low prices



Here are a few samples made to customers specifications . . Our batteries of special high-speed multi-spindle, automatic machines make possible fast and accurate production of hexagon nuts of non-standard height and special shape from carbon or alloy steel, Naval bronze or other non-ferrous metals, also AN 310 through AN 335 as per latest Airforce specifications. Very often the special nut you require may be similar to one we are already making and a simple modification would result in a price advantage and quicker deliveries to you . . Send us your blueprint and particulars —let us quote on your requirements . . We also have a catalog that contains complete specifications, engineering data and prices regarding our standard nuts.

*Also 12 Pointer brochure on request.

NATIONAL MACHINE PRODUCTS COMPANY

Manufacturer of Standard and Special 12 Pointer and Hexagon Nuts . . . "Huglock" and "Marsden" locknuts.

44255 Utica Rd., UTICA, Michigan

Circle 552 on page 19

JUST OFF THE PRESS!

A Valuable Reference for Maintenance Engineers and Original Equipment Designers

The most complete and helpful guide ever published by the originators of mechanical sealing for processing equipment—it illustrates and describes types of Dura Seals engineered to meet your specific temperature, pressure and fluid conditions.

TO RECEIVE YOUR FREE COPY simply send today for the new Dura Seal Catalog No. 480 to:

DURAMETALLIC CORPORATION
DEPT. MD • KALAMAZOO, MICHIGAN

Circle 553 on page 19

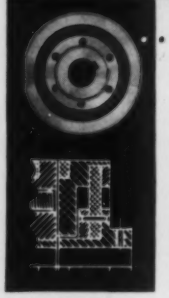
P. S. C. APPLIED RESEARCH LTD., TORONTO, USES TWO ALL AMERICAN VIBRATION FATIGUE TEST MACHINES: ONE FOR HORIZONTAL MOTION, ONE VERTICAL

The busy, modern, laboratory of P.S.C. Applied Research Limited, Toronto, Canada, is equipped with an All American Model 100 HLA-D Vibration Fatigue Test Machine of 100 lbs. capacity and with horizontal table motion and a Model 100 VA-D with vertical table movement. This combination enables them to make a wide range of fatigue tests of components being studied. Automatic Range Selector controls acceleration and deceleration. Send for Catalog showing 7 models and "Introduction To Vibration Fatigue Testing."

ALL AMERICAN TOOL & MFG. CO.
8023 LAWNDALE AVE., SKOKIE, ILLINOIS
Makers of All American Precision Die Filing Machines

Circle 554 on page 19

introducing . . .



. . .The Diaphragm Makes the Difference!

Simplatrol Miniature and Small Electric Clutches and Brakes feature a specially patented diaphragm which is the only moving part in actuation of the clutch or brake. This "heart" of the Simplatrol clutch or brake is good for years of use under the toughest conditions and reduces troublesome magnetization of surrounding parts. Installation of Simplatrol Electric Clutches and Brakes Immediately Upgrades Machines You Make or Use—Gives You Precise As Well As Faster Sequence Operations. Greatly Extends All Functions Of Automatic Control.

Ask for recommendations on Simplatrol units. New illustrated folder on request.

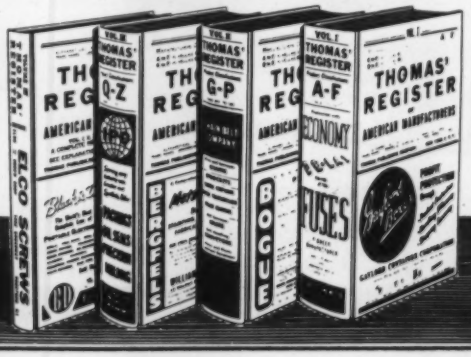
Simplatrol products corp.
24 SALISBURY STREET
WORCESTER, MASS.
Representatives in Key Industrial Areas

Circle 555 on page 19

LOOK FIRST in

THOMAS REGISTER
461 Eighth Avenue, New York 1

45,107 Advertisements describe the products of 11,859 Advertisers



Circle 556 on page 19

LOOK

in this book... over 7,000 STAINLESS STEEL FASTENINGS

RIGHT-OFF-THE-SHELF®

for immediate delivery

STAINLESS STEEL

- Bolt & Cap Screws
- Socket, Set & Cap
- Nuts, Washers
- Machine Screws
- Sheet Metal Screws
- Wood Screws
- Pipe Fittings
- Dowel, Taper, Cotter Pins
- AN Drilled Fillisters
- Stud Bolts

• Avoid costly production and experimental delays! • Brand new 1957 edition of Star Catalog now available.

Write, wire or phone for your copy today!

Stainless Stan says "Star's screws have clean, bright-and-shiny heads"

CORROSION RESISTANT

STAR STAINLESS SCREW CO.

658 Union Blvd., Paterson 2, N. J.
Telephone: Little Falls 4-2300
Direct New York 'phone: Wisconsin 7-9041

Circle 557 on page 19

IN-LINE MARKING

Matthews can furnish you with marking stations integrated with your production line . . . to produce fast, economical product marking. Illustrated is a fully adjustable identity printer for marking filled moving containers.

Gentle, cushioned marking with blanket transfer from interchangeable rubber type has been added to the Famous Matthews' Line. Ask for information on printing your product with permanent or soluble industrial inks.

JAS. H. MATTHEWS & CO.

3938 Forbes St. Pittsburgh 13, Pa.

Philadelphia • Chicago • Clifton, N. J. • Boston • Jacksonville

Circle 558 on page 19

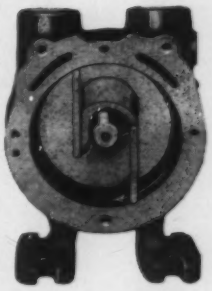
Year after year —Get steady, positive

HIGH VACUUM (up to 29.9" hg.)

or

AIR PRESSURE (up to 20 psig.)

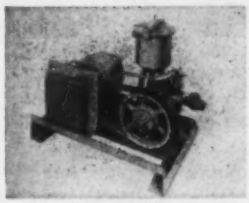
4-WING TYPE. Vacuums to 20" Hg.; pressures to 15 lbs.; displacement to 162 c.f.m. Wings hinged to pistons maintain continuous sealed contact with cylinder walls by centrifugal force. Small pistons, large air chambers, greater capacity.



2-WING TYPE. Vacuums to 29.9" Hg.; pressures to 20 lbs.; displacement to 40.8 c.f.m. Automatic wing adjusting lever forces wear-resistant steel blades to cylinder walls, preventing sticking or binding, maintaining positive vacuum or pressure.

—with Compact, "Lifetime"

LEIMAN *Rotary* AIR PUMPS



New!
Air-cooled High Vacuum Pump
Vacuum to 29.9" hg. 15 to 40.8 c.f.m. Operates at 140°F. Write for folder.

Other types:

- Integral Pump and Motor
- Double Cylinder Type
- Direct Connected models
- Automatic-control units

When you design a machine to operate with specific vacuum, suction or air pressure—specify Leiman Air pumps to be sure of fully-rated capacity for the life of your equipment. Forget about customer complaints, shutdowns or service calls due to air pump trouble.

Leiman Air Pumps are designed and constructed to take up their own wear—provide leakless wing-to-wall seal for years and years. Fewer moving parts—no tips or blades to renew—no maintenance except occasional oiling. Over half a million installed. Representatives and engineering assistance available in all industrial centers. Tell us your needs.

• Write for 12-page Catalog, plus Application Book showing 60 "how-to-do-it" blueprints.

LEIMAN
Rotary AIR and
VACUUM
PUMPS

The "Lifetime" Pumps that take up their own wear

Higher vacuum–larger volume–longer life

LEIMAN BROS., Inc.
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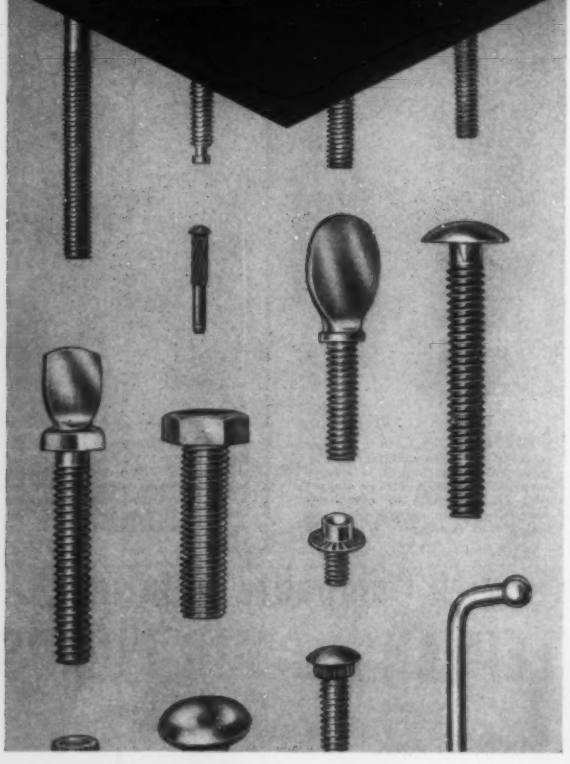
Circle 559 on page 19

Make sure you're buying right

See **PROGRESSIVE** for parts like these



Progressive is saving its customers up to 70% on special fasteners. Very likely we can save you thousands of dollars on many of your small metal components.

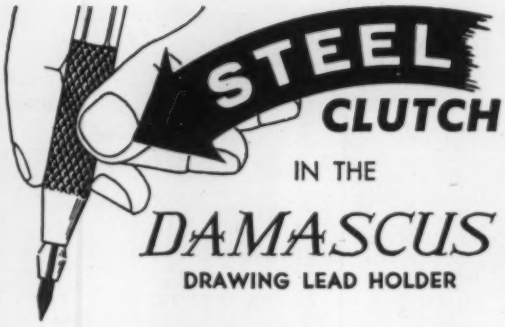
On parts such as these, Progressive's cold forming method is superior to other fabricating techniques. Scrap is eliminated because the metal is formed into shape, not machined away as expensive scrap. Primary and secondary operations may be combined more readily to effect savings in machine time and between-machine materials handling. Work quality is just as you want it—we won't let it out unless it is.

You may have parts right now that our engineers could value analyze for you. Send us the prints. A Progressive quote is a sure indicator that you are buying right!

Machine screws and special fasteners are our business . . .
Including square and hexagon machine screw nuts, Sems fasteners, slotted tapping screws and Phillips Head Screws

STANDARDS AND SPECIALS CUSTOMIZED FOR YOUR NEEDS

THE PROGRESSIVE MFG. CO.
Division of The Torrington Company
52 Norwood Street, Torrington, Connecticut



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DAMASCUS

DRAWING LEAD HOLDER

Balance is in the knurled finger grip for effortless pencil control.

Hardened steel spring loaded clutch grips lead securely — will last for years.

$1.85

Push button anodized red, blue or yellow for quick identification.

Ask your supply house or write for descriptive folder and name of nearest distributor.

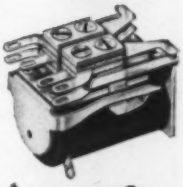
RICHARD BEST PENCIL COMPANY
SPRINGFIELD, NEW JERSEY

Circle 561 on page 19

RELAYS

- FOR INDUSTRIAL USE
- FOR MILITARY USE
- SIMPLE OR COMPLEX
- STANDARD OR SPECIAL

Whatever your relay needs may be, Comar will design and "custom-manufacture" the right relay for you. Electrical characteristics, sizes and mountings are tailor-made to exactly fit your requirements. Precision-engineered, easier to install, more efficient in operation, economical in price. Send for details now!



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Comar ELECTRIC COMPANY
3349 ADDISON STREET CHICAGO 18, ILLINOIS

RELAYS • SOLENOIDS • COILS • TRANSFORMERS • SWITCHES • HERMETIC SEALING

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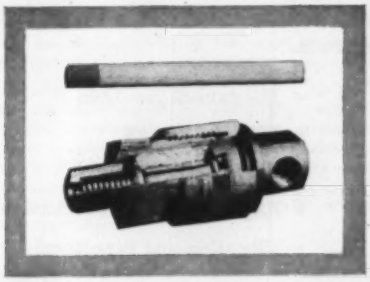
Circle 560 on page 19

NOW TRY HUSCO
Hydraulic Control-Engineering for Improved Performance, —Space and Cost-Saving



Every Husco Hydraulic Control is custom-engineered for your equipment! We have no "standard" models to push. But our successful experience with hundreds of difficult control problems—confirmed by case histories—promises you the *right* control for your needs . . . Control Valves, Check Valves, Reciprocating Valves, Hydraulic Cylinders, Pumps, Power Units—they're all engineered to your specific equipment demands for size, capacity, performance.

Check HUSCO *first* for precision engineered Hydraulic Units. You'll save time, money and worry. Write for details.

HUSCO

HYDRAULIC UNIT SPECIALTIES CO.

Pumps • Valves • Cylinders

Waukesha, Wis.

Circle 563 on page 19

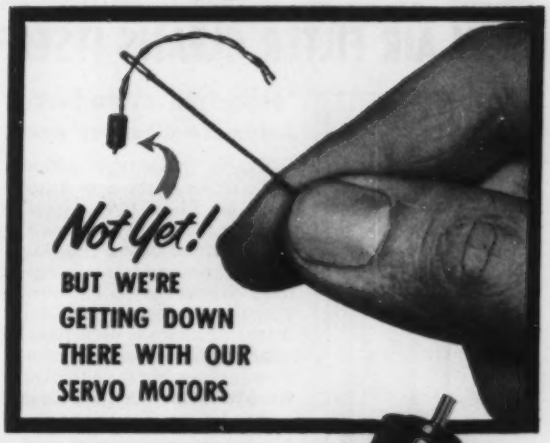
Imperial

the world's finest

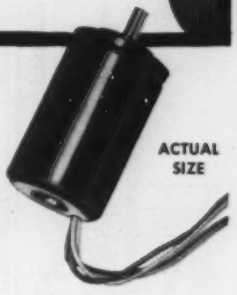
TRACING CLOTH

In drafting rooms throughout the world Imperial quality is the standard by which fine tracing cloths are judged. This has been true for decades, and Imperial remains the finest tracing cloth because its makers have continued to improve its quality and value.

Circle 564 on page 19



TRY THIS NEW FICo SERVO MOTOR FOR SIZE



the SM-58—a truly subminiature servo motor

Nominal Size: ⅝" diam. x 1" long (excluding shaft)

Weight: Under 1 ounce

We believe this is the smallest of small servo motors—and it's a HIGH PRECISION, VERY MODERATELY PRICED unit, with EXTREMELY HIGH torque to inertia ratio.

Applications include

Servomechanisms	Missile Control Systems
Computers	Aircraft Control Equipment
Indicating Devices	—and similar uses

Typical Characteristics include

Line: 26 v 400 cy	No Load Speed: 8800 rpm
Control Voltage: 26 v (max)	Ambient Range: —75 to 200 F
Input: 2-1/2 w	Rotor Inertia: 0.00038 oz-in^2
Output: 1/10 w	Theoretical Acceleration at
Stall Torque: 0.063 in-oz	Stall: 64,000 rad/sec^2

Available with Smooth or Splined Shafts

DELIVERY IS GOOD!

Write to: **Components Sales**

FORD INSTRUMENT COMPANY

Division of Sperry Rand Corporation

31-10 Thomson Ave. MD — Long Island City 1, N. Y.

Telephone: E. McKinnon, ST 4-9000, Ext. 613

California Representatives	*Central and South Central Representatives*
J. F. Sodaro Co.	Automatic General Sales
3895 Main St.	6550-B Troost Ave.
Culver City, Calif.	Kansas City, Missouri

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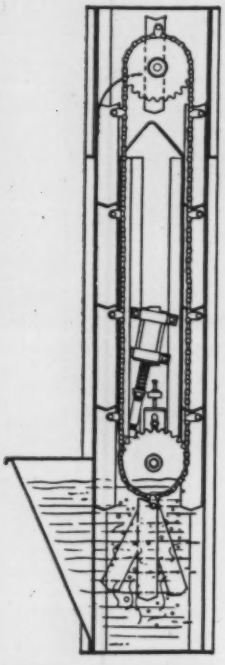
NEW AIR FILTER CLEANS ITSELF



"pulse-type" action keeps Automaze clean as new

Exclusive "pulse-type" action is the secret of the new Automaze air filter. While each panel in the revolving curtain is submerged in the cleaning tank at the bottom, it is agitated vigorously 6 or more times by a compressed air drive. This cleans each panel thoroughly as well as completely renewing the adhesive. Result: Automaze stays clean as new!

New Automaze goes 3 to 6 months without attention—a big improvement over stationary filters that may need cleaning once a month. Even after 6 months, all you need do is remove the sludge. A special reservoir cover makes this a quick, simple operation.

FREE BOOKLET: Send for free booklet for full details on the new Automaze. Write:

AIR-MAZE CORPORATION
25000 Miles Road
Cleveland 28, Ohio

Circle 566 on page 19

MECHANICAL ENGINEERS

Research and Development

Interesting positions open for mechanical engineers on a wide variety of projects in the following fields:

- **Mechanism Analysis**
- **Machine Design**
- **Servomechanisms**
- **Experimental Stress Analysis**
- **Vibration and Structural Dynamics**

B.S. to Ph.D. in mechanical engineering with 3 to 5 years' experience in one of these fields essential. These are permanent positions offering an opportunity to use your initiative and creative ability. We offer excellent employee benefits including tuition free graduate study. For employment application, call Calumet 5-9600, or write

Mr. J. A. Metzger

ARMOUR RESEARCH FOUNDATION
of
Illinois Institute of Technology
10 West 35th Street
Chicago, Illinois

Circle 567 on page 19

FLOW SIGHTS

SHOW "WHAT GOES ON" IN YOUR PLANT OR IN YOUR PRODUCT

Tell when liquids are moving, if quality is right and indicate flow.

Fig. 54A
Flow Sight

Available in many sizes and types, usually from stock!

Plant and product engineers have relied on Bowser, liquid handling specialists since 1885, for prompt service. For sight glasses in single or double-window types, gravity or pressure models; or for electric or mechanical indicators . . . there is a Bowser man nearby ready to help you . . . quick!

Fig. 811
Flow Indicator

Fig. 816
Teleflo Indicator

PRODUCT OF BOWSER RESEARCH

WRITE FOR FLOW DEVICES BOOKLET

BOWSER, INC., 1314 E. CREIGHTON, FT. WAYNE, IND.

Circle 568 on page 19

Design Guide to

"Adjustable-Speed Drives"

- **ELECTRICAL**
- **MECHANICAL**
- **HYDRAULIC**

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

$2.00
per copy

MACHINE DESIGN READER SERVICE
Penton Building Cleveland 13, Ohio

MECHANICAL ENGINEERS

Pioneer for Growth . . .

A challenging future with a small growth company is offered the engineer who is interested in a career opportunity utilizing his training and technical know-how.

Responsible engineering positions exist in the machine design and development of xerographic equipment. Xerography, a process for forming and using electrostatic images, is widely used in the copying and duplicating fields. It is being developed for fascinating applications in automatic data processing, photography, office equipment, engineering drawing systems and interesting military applications.

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Previous experience in the design of office equipment or photographic equipment (military or commercial) would be helpful.

- Comprehensive Employee Benefit Program
- Exceptional Tuition Refund Program
- Ideal living and recreational area

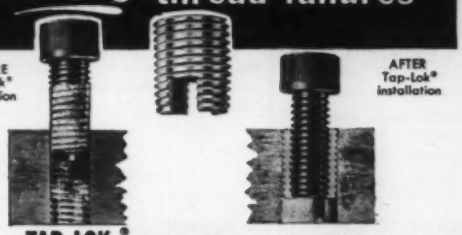
Kindly send resume and salary requirements to:

David S. Raub
Industrial Relations Division
The Haloid Company
Rochester 3, New York

HALOID

Circle 569 on page 19

This ounce of prevention *cures* thread failures



. . . TAP-LOK,® the self-tapping insert

Fabricators of aluminum, magnesium, plastics, etc., have found that Tap-Lok Inserts provide the most practical solution to the problem of increasing the thread-holding strength of comparatively weak materials.

The Tap-Lok Insert is designed as a permanent fastener in materials which are machinable but of insufficient shearing strength to sustain applied loads in threads tapped directly into them.

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Their unique self-tapping feature substantially reduces assembly costs by eliminating separate tapping operations, hole preparation, secondary staking.

Used widely as original equipment, Tap-Lok Inserts are also ideal for salvage and repair of stripped threads.

Send for your free copy of our new 12 page booklet on Tap-Lok Inserts.

Also manufacturers of Groov-Pins for positive locking press fit.

GROOV-PIN

GROOV-PIN CORPORATION

1130 Hendricks Causeway, Ridgefield, New Jersey

Representatives in principal cities throughout the U. S. A.
In Canada: Metal and Wood Fastening Devices Co., Valois, Montreal

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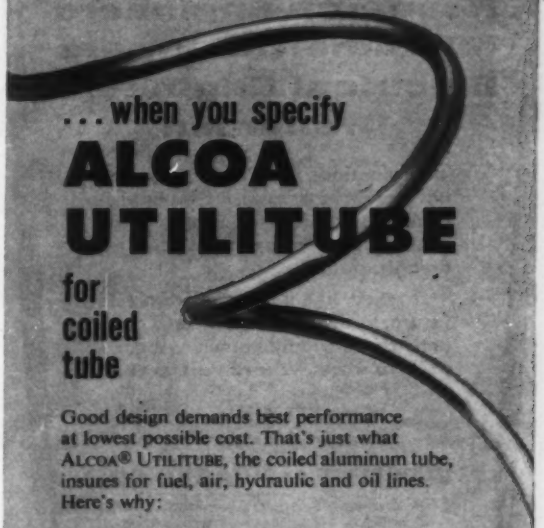
Good design can cost 40% less



. . . when you specify ALCOA UTILITUBE for coiled tube

Good design demands best performance at lowest possible cost. That's just what ALCOA® UTILITUBE, the coiled aluminum tube, insures for fuel, air, hydraulic and oil lines. Here's why:

LOW COST—actually costs up to 40% less per foot than copper tube.

LONG LENGTHS—available in economical long lengths up to 1,000 feet.

EASY WORKABILITY—bends easily, work-hardens less.

CORROSION RESISTANT—resists most industrial atmospheres, many gases and liquids.

LIGHT WEIGHT—only ⅓ the weight of copper; long lengths easier to handle.

NO SLUDGE OR GUM—will not contribute to the formation of sludge or gum in lubricating oils, gasoline.

AVAILABILITY—your ALCOA distributor carries ample ALCOA UTILITUBE in stock.

FITTINGS—readily available in aluminum from several manufacturers.

Get complete details in the free booklet, *Alcoa Utilitube*. Use the handy coupon.

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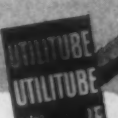
ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA



ALUMINUM COMPANY OF AMERICA
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Pittsburgh 19, Pa.
Please send me the free booklet, *Alcoa Utilitube*.

Name _____ Title _____
Company _____
Address _____
City _____ Zone _____ State _____

Circle 571 on page 19

Research Engineers
Machine Designers
Electrical Engineers
Draftsmen

• Promotions within our company have created a number of opportunities for qualified men to grow with our growing engineering organization.

If you'd like a career with a real future, with a long established company that's widely known as a good place to work, write or visit us now!

Write: **C. T. Blake,** *Mgr.*
Director of Engineering

WARNER & SWASEY CO.
5701 Carnegie Avenue, Cleveland 3, Ohio

Circle 572 on page 19

Small Company—

Big Opportunity

We are looking for two exceptional, qualified ENGINEERS to fill important administrative engineering positions.

Qualifications must include a B.S. in Engineering and proven ability in the supervision of engineering personnel. Ability to coordinate work efforts with the efforts of other groups, departments, companies, and government agencies is essential.

Experience in electro-mechanical, office equipment or photographic fields would be helpful.

Imagination and inventiveness is required, plus the capacity for personal growth in a pioneering organization located in upper New York State.

Please submit resume and salary requirements to:

Box 913
MACHINE DESIGN
Penton Bldg. Cleveland 13, Ohio

MACHINE DESIGN
ENGINEERS

who can meet the challenge of keeping our automatic tube production equipment the most modern and efficient in the country.

You'll work and live in delightful upstate New York (Elmira) where lovely homes, fine schools and excellent shopping are minutes apart. Near famous Finger Lakes year 'round vacation land. Fishing, hunting, boating, swimming.

FIND OUT TODAY about the opportunities for you in the design of automatic machines for production of electronic tubes. Experience in the design of special purpose medium weight automatic machinery required. Vacuum tube equipment experience desirable but not essential.

Phone 9-3611 collect, or send resume to Mr. W. Kocela, Dept. M-1A2.

Westinghouse

ELECTRONIC TUBE DIV. ELMIRA, N. Y.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

ENGINEERS
AVAILABLE OR WANTED

WANTED: Engineers, mechanical and electrical, for design and development of machine tools. Hydraulics, electronics, and servo-mechanisms. Inquiries held confidential. The Monarch Machine Tool Company, Sidney, Ohio.

WANTED: An expanding midwest pharmaceutical company has opportunities available for mechanical or industrial engineers with creative ability and interest in design and installation of pharmaceutical packaging equipment. Also opportunities in a Methods and Standards Department. Prefer engineer with experience in time standards, manufacturing methods, and management controls. Excellent working conditions include 40 hour week, complete insurance and retirement plan, and liberal vacation policy. Write stating background and experience to Employment Office, The Upjohn Company, Kalamazoo, Michigan.

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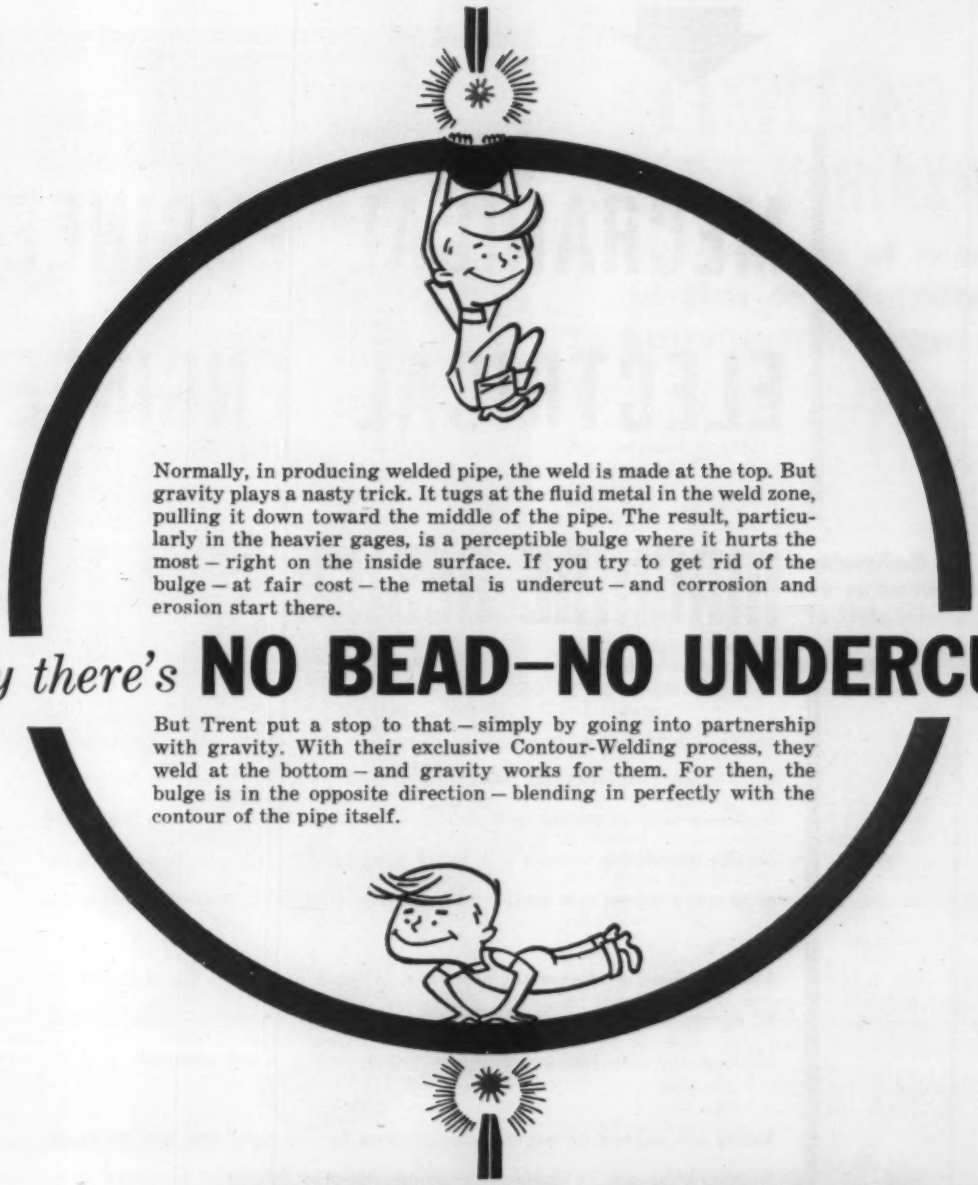

Normally, in producing welded pipe, the weld is made at the top. But gravity plays a nasty trick. It tugs at the fluid metal in the weld zone, pulling it down toward the middle of the pipe. The result, particularly in the heavier gages, is a perceptible bulge where it hurts the most – right on the inside surface. If you try to get rid of the bulge – at fair cost – the metal is undercut – and corrosion and erosion start there.

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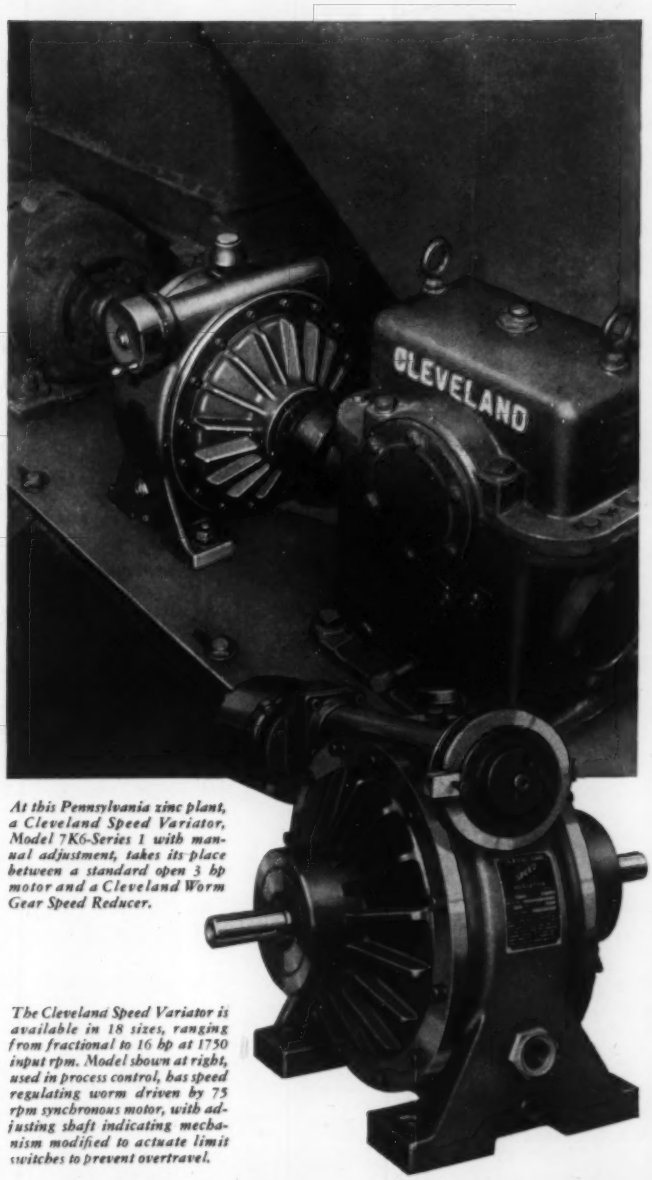


At this Pennsylvania zinc plant, a Cleveland Speed Variator, Model 7K6-Series 1 with manual adjustment, takes its place between a standard open 3 hp motor and a Cleveland Worm Gear Speed Reducer.

The Cleveland Speed Variator is available in 18 sizes, ranging from fractional to 16 hp at 1750 input rpm. Model shown at right, used in process control, has speed regulating worm driven by 75 rpm synchronous motor, with adjusting shaft indicating mechanism modified to actuate limit switches to prevent overtravel.

CLEVELAND SPEED VARIATOR

adjusts rate of feed of zinc concentrate to hammermill's capacity

DRY, partially roasted, zinc from a new roaster at one of the most important zinc smelters of Western Pennsylvania is fed from the bin to the hammermill by a 12″ screw. Delivery to the hammermill must be varied over a wide range as the demand indicates. The easiest way to vary the feed was, of course, to drive the screw at variable speeds —and the Cleveland Speed Variator was selected for the job.

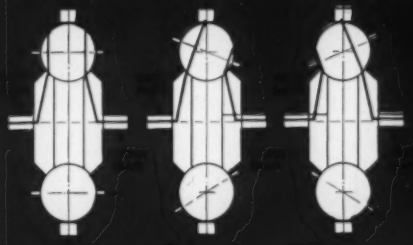
Being infinitely variable, the Cleveland Speed Variator gives stepless speed over a full 9:1 range —from ⅓ to 3 times input speed. Output speed on this application is adjusted by the hand wheel on the Variator—but could be regulated by either manual or automatic remote control.

The Cleveland Speed Variator offers these major advantages:

1. An extremely compact unit with input and output shafts in line and rotating in the same direction.
2. Almost any input speed up to 1800 RPM can be used—either clockwise or counterclockwise rotation.
3. Rated for constant horsepower output over a 9:1 or 6:1 range; or for constant output torque over a 6:1 range.
4. Speeds infinitely variable over entire range of adjustment.
5. No slippage—positive torque response mechanism adjusts in direct proportion to the loads encountered.
6. Long life and minimum maintenance due to absence of belts or complicated linkages.
7. Ample bearing support for overhung pulleys on either input or output shafts.

Write for Bulletin K-200 for detailed description with photographs, sectional drawings, rating tables and specifications.

HOW THE CLEVELAND SPEED VARIATOR WORKS



THE CLEVELAND WORM AND GEAR COMPANY

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Again and Again and Again

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THE MARK OF BETTER MACHINES

W. F. & John Barnes, a leading builder of machine tools and automation installations, standardizes on the use of Cutler-Hammer motor control equipment

Barnes Multiple Station "Progress-Thru" Machine which performs a total of 54 operations on automotive cylinder heads in a continuous automatic cycle. Cutler-Hammer Three-Star Motor Control and Heavy Duty Oil-Tight Pushbuttons are standard original equipment.

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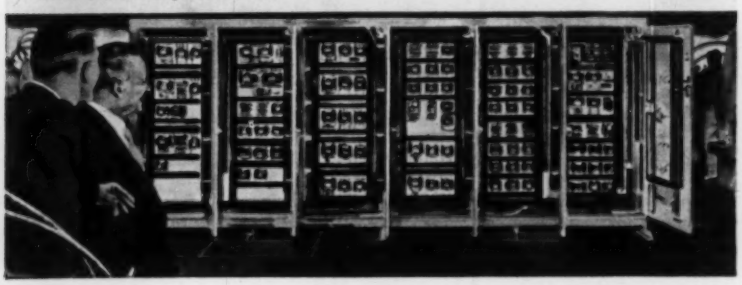
Control cabinet doors of Barnes machine opened to show array of Cutler-Hammer Three-Star Motor Control components used.



The W. F. & John Barnes Company, Rockford, Illinois, has designed and built highly specialized mechanical, electrical and hydraulic equipment and machines for more than 80 years. Their unusually competent Electrical Division has repeatedly won distinction in the custom designing and building of complex electrical control systems, particularly in advanced automation engineering. Their choice of Cutler-Hammer Three-Star Motor Control and Cutler-Hammer Heavy Duty Oil-Tight Pushbuttons, in their own words, "simply reflects our conviction that these are the very best available."

Cutler-Hammer Three-Star Motor Control and Cutler-Hammer Heavy Duty Oil-Tight Pushbuttons are the decided preference of able engineers whenever selection is determined by careful comparison. To be sure, you too should standardize on Cutler-Hammer . . . the choice of the leaders, the mark of better machines.

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CUTLER-HAMMER
MOTOR CONTROL
C-H

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